DRAFT
Pre-Meeting Peer Review Summary Report

External Peer Review of EPA's Draft Document

An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

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I. INTRODUCTION

In February 2011, NCEA announced a scientific assessment of Alaska's Bristol Bay watershed to understand and examine how future large-scale mining development projects may affect water quality, habitat, and salmon fisheries in the Bristol Bay watershed, which is home of one of the largest salmon populations in the world. EPA's assessment will focus primarily on the Nushagak and Kvichak River drainages, as they are the primary areas in the watershed open to large-scale development.

This assessment was launched in response to concerns from Federally recognized tribes and others, who petitioned the Agency regarding potential impacts of large-scale mining on aquatic resources. The assessment will examine if large-scale mining development is likely to have adverse impacts on salmon and resident fish populations of the Kvichak and Nushagak River drainages, and if these effects are likely to affect wildlife and human populations in the region. The assessment is not decisional.

The purpose of the peer review is to identify any problems, errors, or necessary improvements to the report prior to being published or otherwise released as a final document. As the assessment is not decisional, reviewers are not reviewing an EPA decision.

PEER REVIEWERS

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II. CHARGE TO REVIEWERS

Charge Questions

Please provide narrative responses to each of the 14 charge questions below.

1) The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?

2) A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?

3) EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?

4) Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?

5) Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?

6) Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant

literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

7) Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

8) Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

9) Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

10) Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

11) Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?

12) Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?

13) Does the assessment identify and evaluate the uncertainties associated with the identified risks?

14) Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?

III. GENERAL IMPRESSIONS

David A. Atkins, M.S.

The Bristol Bay Watershed Assessment (the Assessment) presents a comprehensive overview of current conditions in the Watershed and establishes the uniqueness and global importance of the area to global salmon ecology (e.g., nearly 50% of the global sockeye salmon population comes from Bristol Bay and nearly 50% of the salmon in Bristol Bay come from the Nushagak and Kvichak Rivers, which encompass nearly half of the watershed area and where the proposed mineral development projects are located). The report also describes in detail the importance of the fishery to Native Alaska cultures, the importance and uniqueness of subsistence activities, and the scale of the commercial fishery. The report also properly outlines the reliance of the local economy on the salmon fishery.

There is no question that a mine, especially of the type and magnitude described in the study, will have significant impacts and that if these impacts are not or cannot be properly managed and/or mitigated, the consequences could be profound. The mining scenario presented in preliminary documents prepared for the project proponent and presented in the Assessment sets out a conventional approach to mine development that is in frequent use today for this type of mineral deposit, including open-pit and block-cave underground mining methods and waste rock and tailings management. Development of the mine would eliminate streams and wetlands in the project area permanently, and it is unclear if this impact could be mitigated. It would be helpful for the authors to put this impact in context of the watershed as a whole to allow readers to better understand the importance.

The risk of failure of the tailings facility and the potential for long-term acid and metals production from waste rock is described in detail in the Assessment and present the biggest long-term risk from project development. More conservative and innovative engineering could decrease the possibility of failure.

Under the mining scenario described, perpetual management of the geotechnical integrity of the waste rock and tailings storage facilities and perpetual water treatment are a certain necessity, and failure is always a possibility, albeit a possibility that is difficult to quantify with any degree of certainty as described in the Assessment.

Construction of the mine as presented would effectively replace a natural ecosystem that is rich in diversity and that provides certain ecosystem services (including salmon spawning and rearing habitat and resident fish habitat) with an engineered system that will require perpetual human intervention, would be unlikely to provide the same biological diversity and ecosystem services, and that has multiple failure modes that could lead to further impact.

Steve Buckley, M.S., CPG

The assessment attempts to evaluate the potential impacts of mining development in the Nushagak and Kvichak watersheds. The main deficiency in the assessment is that it uses only two hypothetical mine scenarios to bracket the potential impacts of mining activities on the ecological resources in the watershed. Both of these mine scenarios are larger than the 90th percentile of all porphyry copper deposits in the world. In order to properly assess the potential effects of mining activities, in the absence of any specific mining proposal, a minimum mine scenario on the order of the 50th percentile of worldwide porphyry copper deposits would be more appropriate. Three or four mine scenarios would allow for a broad range of analysis, and the reader would be able to put the potential impacts of mining development in wider perspective.

A large part of the assessment provides information related to catastrophic potential system failures such as tailings dam failures and pipeline ruptures. There is inadequate information on, and analysis of, potential mitigation measures at the early stages of mine development, which would attempt to reduce the impacts of mining activities on fish and water quality. The bulk of the document is dedicated to evaluating the impacts of tailings dam failure on aquatic resources and yet, in Chapter 4, the assessment provides a probability of tailings dam failure at 1 in every 2,000 mine years.

The assessment identifies the interconnectivity of groundwater, surface water and fish habitat as being a major component of the quality of the fishery in the watershed, yet puts relatively little effort into the analysis of the detailed relationships between groundwater, surface water, water quality and fish habitat, even though this is likely the most important factor in assessing the potential impacts of mining activities on the fisheries in the watershed.

Additional mine scenarios and a more detailed investigation of the geomorphology, surface and groundwater hydrology and their relation to fish habitat would provide the reader with a more accurate and more useful scope of analysis.

Courtney Carothers, Ph.D.

Synopsis: EPA's draft document examines the potential impacts of large-scale mining development on the quality, quantity, and genetic diversity of salmonid fish species in the Nushagak River and Kvichak River watersheds of Bristol Bay, Alaska. To the extent that both wildlife and Alaska Native communities in the region depend upon salmonids, fish-mediated impacts to these other "endpoints of interest" are also explored. A hypothetical mining scenario, informed by current exploration, planning, and study in the Pebble deposit area, is described using minimum and maximum estimates for mine production and includes the construction of a transportation corridor to Cook Inlet. Even in the absence of any failures or accidents, construction and operation of such a mine would have significant impacts to salmonids in stream systems proximate to the mine footprint with some related impacts to wildlife and human communities. At least one or more accidents or failures are expected to occur over the long lifetime of the mine. Immediate and long-term severe impacts to salmonids are expected to occur with any significant failure, with relatedly pronounced impacts to wildlife and Alaska Native communities in the region. Multiple mines in the region would amplify these impacts.

General impressions: Overall, the main report is well-written and presents information in multiple ways, including: narrative, conceptual models, images, figures, and tables. The report synthesizes a large amount of information, much of which is described in detail in the report's appendices. The report highlights the unique characteristics of this watershed: incredibly productive and sustainable salmon fisheries, relatively little large-scale modification of the natural environment, and active subsistence-based indigenous cultures still occupying their homelands and many still using their Native language. Making central these features of the watershed, the tone of the report suggests that some negative impacts to salmonids, wildlife, and Alaska Native communities are necessarily expected to accompany any large-scale mining development and operation in this region.

More information could be given on the scope of this assessment. For example, the report could articulate more clearly why Alaska Native cultures are the only human groups included in the assessment of fish-mediated human impacts. The report notes: "because…Alaska Native cultures are intimately connected and dependent upon fish, …the culture and human welfare of indigenous peoples, as affected by changes in the fisheries are additional endpoints of the assessment" (ES-1-2). This suggests that the limitation of human considerations to Alaska Native cultures is not due to the special political relationship tribal governments have with the federal government, nor the special status afforded by environmental justice concerns (EO 12898), but rather because of their close connection and dependence on fish. This rationale should be further clarified. This comment is not meant to detract from the importance of the focus on Alaska Native cultures and the primarily indigenous communities in this region for assessing fish-related impacts. Rather the comment is made to suggest the inclusion of a clear statement for this single focus, especially as other groups, who arguably also rely on salmon in this region, are excluded from the analysis of potential impact. Additionally, the assessment of fish-mediated affects to Alaska Native cultures is primarily focused on subsistence fisheries. More discussion of the role of commercial engagements in salmon fisheries (e.g., commercial harvesting, processing, recreational fishing businesses and employment) in the watershed communities in this region would be helpful. Substantial information on the economic dimensions of salmon resources in this region is summarized in Appendix E, but little is presented in the main report.

Dennis D. Dauble, Ph.D.

Overall, the main report and each of the accompanying appendices were well written and organized in manner that was easy to follow. I was unable to identify any inaccuracies or bias in the material. The assessment effectively addressed three time periods: operation, post-closure and perpetuity. Potential effects are bounded by a minimum and maximum mine size, which is also appropriate. What is different about this risk assessment than most others is the inclusion of inference by analogy. This approach strengthens the assessment (and helps validate) results obtained from model predictions.

Most figures and tables were useful. Value of the conceptual model discussion and accompanying illustrations of potential habitat effects (Figures 3-2A and C) was somewhat limited in that they provide a simplistic view of what are more complicated pathways and relationships among potential activities and environmental attributes. These relationships are not revisited in any detail later in the document perhaps due the difficulty of quantifying changes across the range of potential effects of mining activities.

The Integrated Risk Assessment (Chapter 8) did a creditable job of summarizing habitat losses and risks from mine operations. What's missing, however, are quantitative descriptions of habitat lost relative to total habitat available in the larger watershed and individual systems. If anything, the conclusions could be strengthened. The summary of uncertainties and limitations

(Section 8.5) dwells on things that "could not be quantified" due to lack of information, model limitations or insufficient resources. Thus, this reader was left somewhat in limbo as to the potential magnitude of effects from mining activities. (Note that this "neutral voice" is carried through to the Executive Summary). Many people might interpret such statements of uncertainty as no proven effect. My point is that probable environmental consequences of mining activities are much greater than this report alludes to.

Gordon H. Reeves, Ph.D.

The report was very good and the authors should be commended for producing such a quality report in the time that they were given. The authors appeared to have thoroughly considered available literature and reports on all aspects of the mine, its operation and the parameters that could be affected by it. Assumptions about the location and operation of the Pebble Mine seemed reasonable and the authors clearly articulated limitations of available data and other information concerning the mine's location and operation. I found the consideration of the mine during the various phases of development and operation and the discussion about potential development of other mines in the area particularly insightful. Inclusion of experiences from other mining operations was also helpful in understanding the conclusions about potential impacts of the mine and its operation over time. Additionally, the consideration of the potential development of other mines in the area was particularly insightful and provided a good picture, albeit not in depth, of potential cumulative effects on aquatic resources in the Bristol Bay area.

Parts of the report on the ecology of fish and aquatic ecosystems, road, and culverts, topics that I am familiar with, were covered very well and the conclusions about potential impacts of the mine and its operation generally seemed justified. The authors presented available data and information on fish distribution and abundance relative to the presumed location of the various components of the mine operation. Their analyses were appropriate and limitations of the results were readily acknowledged. I assumed that the findings about mine operation, such as failure rates of tailing site facilities, roads, pipeline failure, etc., and toxicology, were similarly plausible because the findings about potential impacts on subjects that I have knowledge seemed reasonable and were supported by the analyses presented. I would need to reconsider my assessment if this assumption was incorrect.

Charles Wesley Slaughter, Ph.D.

Provision of full-color versions of all figures would have been helpful to the reviewers.

The Assessment (Volume 1 – Main Report) provides a fairly comprehensive review of fisheries-driven issues, from the perspective of salmonids. Appendices (Volumes 2 and 3) are very informative. The high significance of Bristol Bay watershed, and specifically of the Nushagak and Kvichak river systems, for commercial fisheries on the global scale and for sport and subsistence fisheries at the regional and local scales, was appropriately described.

The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem, if anything, understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with less attention on "salmon-mediated" impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

Chapter 2 (Characterization of current condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region.

The "Water Management" section (4.3.7) seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated"; "water from these upstream reaches would be diverted around and downstream of the mine where practicable"; "Precipitation…would be collected and stored…."; do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen), would be planned for or actually managed adequately.

Perhaps I missed it, but I found no acknowledgment of the potential presence of or consequences of perennially frozen soils – permafrost – in the Bristol Bay watershed, or more specifically in the Pebble ore deposit locale or the proposed transportation corridor. Selkregg's (1976) Fig. 136 shows soils of the Pebble locale as INT/2g, INT/1g – HYP, or SOU/2g-HYP – that is, well-drained gravelly soils (INT) or well-drained acidic soils (SOU) with interspersed peaty, poorly-drained shallow discontinuous permafrost. There is abundant literature on the influence of permafrost on engineered structures, roads, hydrology, etc. Even if the bulk of the terrain involved in the proposed Pebble mine, road and infrastructure project is founded on well-drained gravelly soils, any interspersed permafrost-underlain terrain can prove problematic in terms of landscape stability, potential erosion, and consequent structural, engineering, hydrologic and water quality issues. See a few suggested references**.**

While there is extensive discussion of a proposed transportation corridor, there was no mention of construction of a major airfield. A project of this magnitude would undoubtedly require development of a facility in close proximity to the mine(s) capable of handling C130 and commercial jet passenger and cargo traffic, at least to the 737 class, if not 747. I don't know what the footprint for such an airfield would be, but it would be substantial, and with requisite roads, fuel handling, etc., would be a major project in itself. This would seem to be a logical component of a comprehensive assessment of the potential Pebble project.

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure, which would follow an initial mining project. A truly comprehensive analysis should incorporate full analysis of these aspects.

John D. Stednick, Ph.D.

The document characterizes the potential environmental effects of an open pit mine over a copper porphyry complex in southwest Alaska using a hypothetical mine design based on similar complexes elsewhere, particularly the Fraser River in British Columbia. Environmental consequences were estimated by the environmental risk assessment model approach for both 'no failure' and 'failure' scenarios. The Executive Summary emphasized the effects of mine development on salmon resources and indigenous peoples under the development and closure scenarios with tabular summations of risks (probabilities). The conclusions of the Executive Summary are often strongly worded (e.g., pages ES 13-24), yet do not always parallel the certainty of presented materials. The discussion of uncertainties and limitations may temper those conclusions.

Characterization of current conditions is too brief. More information \is needed for a full site characterization. Any reader unfamiliar with the setting would not fully appreciate the physical, biological, and ecological linkages that occur in the study area. The risk assessment of failure and no failure are covered in Chapters 5 and 6 with varying levels of detail and substantiation of conclusions. Statements like, salmon is important in the human diet, thus a salmon loss affects human health, seems like a weak argument. Chapter 8 "Integrated Risk Characterization" reads like a summary chapter, rather than integrating the risks. Cumulative effects are not addressed *per se*, so much as multiple mines in the study area; they are not the same. CEQ has guidelines available for cumulative effects analyses.

Roy A. Stein, Ph.D.

Accuracy of Presentation. Overall, I was pleased with the accuracy of the presentation. Typically, peer-reviewed citations to the scientific literature were cited as supportive documentation for most all of the factual information. Unfortunately, many data are missing, especially with regard to sockeye populations (as well as other salmonids), their diversity, their relative size, their distribution across the watershed, their vital rates (i.e., recruitment, growth, and survival across life stages), and to what extent the Pebble Mine and its associated activities will reduce these populations (for there is no question they will indeed be reduced through both the mine footprint and allied operations), both through impacts on individual populations and the overall production of sockeye salmon in the Bristol Bay watershed. Whereas, I am relatively confident about the accuracy of the fisheries information, I cannot comment in detail regarding the accuracy of the mining information or impacts on the Native Alaskan cultures. These sections seemed well presented and appropriately supported with citations, but they lie beyond my expertise.

My concerns about the document revolve around issues that were not considered, i.e., Global Climate Change, "In Perpetuity" issues, groundwater-surface water exchange issues (owing to missing information), impacts of Routine Mine Operations in a more realistic setting, and other somewhat more minor issues (see comments below). With any revision, the authors could include this information by eliminating redundancy (see below), thereby not increasing document length.

Clarity of Presentation. Generally speaking, I believe that the writing was intelligent, reasonably insightful, and, more specifically, on task. My greatest criticism with regard to the presentation revolves around the organization of the document. As detailed below, the organizational scheme lent itself to redundancy, from the Introduction through the various chapters to the Integrated Risks Characterization chapter. Owing to this redundancy, the report is likely too long by about 20% and any revision should serve to improve its impact on readers.

Soundness of Conclusions. The conclusions were well supported, where there were published data to support them. Many statements that could be interpreted as conclusions were often more qualitative than desirable in a review document such as this one, owing to the lack of information (percent of sockeye lost owing to routine mine operations, impacts of mining on wetlands, extent of groundwater-surface water disruptions, just to name a few). Consequently, the soundness of the conclusions are somewhat compromised by a lack of information.

William A. Stubblefield, Ph.D.

The document "*An Assessment Of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska*" is a well-written, comprehensive document that employees a risk assessment-type approach to an *a priori* evaluation of potential environmental effects on the ecosystem and potential receptor species (e.g., salmon) that may be affected by a potential copper mine located in the Bristol Bay area of Alaska. This document is somewhat unique in that no actual mine has been proposed at the location and few site- or project-specific data are available. Therefore, no specific information about development plans and potential operational and closure activities associated with the mine are available. Rather, the authors have attempted to develop a hypothetical mine and attempted to assess possible environmental effects associated with mine development, operation, and closure. Although interesting, the potential reality of the assessment is somewhat questionable. It is also unclear why EPA undertook this evaluation, given that a more realistic assessment could probably have been conducted when an actual mine was proposed and greater detail about operational parameters were available. The approach taken in the document attempted to be comprehensive and evaluated a variety of scenarios that may affect aquatic resources in the Bristol Bay region. Given the importance of salmon populations in the area, both from a financial and societal perspective, it is important that a comprehensive evaluation of potential environmental effects associated with mine development and operations be conducted. The authors have attempted to conduct such a comprehensive evaluation and have attempted to quantify (to the extent possible) the probability of adverse effects occurring. Implementation of this approach is proper and with the correct data, can provide a comprehensive evaluation of potential environmental effects. Unfortunately, because of the hypothetical nature of the approach employed, the uncertainty associated with the assessment and therefore the utility of the assessment is questionable.

A variety of uncertainties and data needs were identified as a result of this effort and this alone may provide sufficient value for the document and approach. For example, the authors note that there is not an abundance of chronic toxicity data considered in deriving the EPA's ambient water quality criteria for copper and that there is an uncertainty associated with whether the biotic ligand model (BLM) adequately protects species of concern in Bristol Bay. It would seem appropriate for EPA (perhaps in concert with industry) to develop the data to improve our understanding of copper toxicity and to ensure that regulatory standards are in fact appropriate for their intended use. A substantial body of data evaluating copper chronic toxicity has been developed by the copper industry as a result of regulatory requirements driven by the European REACH regulations. It may be beneficial for EPA to examine these data, thus resulting in a reduction in any uncertainty associated with the evaluation of environmentally acceptable metals concentrations. It should also be noted that similar data sets exist, and biotic ligand models exist for number of other metals that may be of concern at the Bristol Bay site.

Dirk van Zyl, Ph.D., P.E.

The draft report contains a large amount of information and was clearly written by a group of people having little time for conciliation of all the statements and evaluations. It is unclear to me how many of the participating team members truly understand the development, operation and closure of a mine of the magnitude discussed.

It seems to me that the accuracy of information for a hypothetical mine cannot be high quality as it is for a conceptual mine. However, some sections of the report contain highly detailed evaluations, such as stream lengths, water body areas and number of bridges and culverts on the road from the mine to the port facilities. It is not appreciated that there can be considerable uncertainty/variability in these values if small changes are made in the conceptual mine development plans.

In the area of my expertise, which is mining, there are a number of concerns with the report, for example at least one reference is misquoted, concepts are incorrect and significant example case studies are not included. I would not accept this report as a final term paper in one of my graduate courses, e.g. Advanced Mine Waste Management and Mining Environment Case Studies as it needs significant edits and updates before it is of sufficient technical quality with respect to attention to specific technical information in the applicable literature, appropriate concepts for analysis and overall attention to the practical aspects of the problem at hand.

Phyllis K. Weber Scannell, Ph.D.

The document "An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska" and the accompanying appendices provide an in-depth and thoroughly documented description of the environment and resources of the Bristol Bay region and, especially, of the areas under consideration for mineral development. Appendices A and B are particularly thorough in describing the salmon and non-salmon fishes in the region; the discussion of species specific fish sensitivities to certain toxicants adds important information for future consideration of project development.

The assumptions for developing and operating large porphyry copper mine may not be aligned with features of a future mineral development project. Too much emphasis was placed on effects of catastrophic failures, such as failure of a tailings dam or pipeline and too little emphasis on the need to identify and control seepage water, run-off from PAG and NAG waste rock areas, and water treatment.

The document discussed effects of dewatering on suppressing stream flows and groundwater inputs but did not consider effects of the discharge of treated wastewater. The need for bypassing all clean water sources around a development site should be addressed.

The cultural characterizations and effects on human populations from large mine development are outside my area of expertise; therefore, I cannot comment on the adequacy of the information.

As stated in my response to charge questions, I believe that the two most important questions for mineral development in this region are: Can a mine be designed and operated for future closure? and, if not, is it acceptable to develop a large porphyry copper mine that will essentially require perpetual treatment? These two questions must be addressed when considering protection of the fish, wildlife and human resources of the region.

Paul Whitney, Ph.D.

Response (with a wildlife perspective) – The documents read well and have received a good text edit. The summary write ups of several species of wildlife (Appendix C) are very good regarding natural history and tend to focus on the proposed mine site and less on game management units in the Kenai Mountains along the proposed haul road.

A variety of authors have obviously contributed to the documents and it appears that the direction given to them or their interpretation of goal statements varies. For example, if the goal of the assessment was to evaluate the risk to wildlife due to risk to fish (Executive Summary, page 1, last para) it's not clear why so much verbiage in Appendix C was devoted to species such as caribou that are not closely associated with fish. Information in the wildlife write ups could be used to assess direct impact if the scope of the assessment were to be expanded. For example, if the goal was to assess the impact of potential mining on the ecosystem (see Executive Summary page 1, para 1), the information on caribou is more relevant. The apparent diversity of goal statements cited in the assessment gives me mixed messages regarding the clarity of the presentation (see more detailed discussion below).

The charge question related to wildlife asks for an evaluation of the risk to wildlife due to the risk to fish. If the risk to fish cannot be quantified because there is little or no demographic information, then any evaluation of risk to wildlife can't be quantified and must be qualitative. Merely stating that a qualitative increase in risk to fish will also result in a qualitative increase in risk for wildlife is not adequate. I am not satisfied with such an obvious and general conclusion. I do not understand why the scope of the documents is limited to an indirect evaluation of fish caused risk to wildlife. The following responses to charge questions leans more toward an ecosystem evaluation that includes not only risk of fish to wildlife, but also risk of direct wildlife and vegetation loss to fish and indirect risks to wildlife such as noise and human presence.

IV. RESPONSE TO CHARGE QUESTIONS

Charge Questions

Question 1. The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?

David A. Atkins, M.S.

Based on my general understanding of the Bristol Bay watershed, I consider the **baseline** information presented in the USEPA Bristol Bay Watershed Assessment (the Assessment) accurate and sufficiently complete for the endpoints of this watershed assessment in the following areas:

- General view of Pacific salmon populations
- General view of resident (non-anadromous) fish
- Wildlife populations
- Native cultures

The Assessment also describes in detail the current economics of the watershed, including commercial and sport fishing and subsistence activities.

The report highlights several aspects of the area that make the fishery unique in both its abundance and diversity:

- The unique hydrology of the area (strong groundwater and surface water interaction) that contributes to stable flows and temperatures favorable for salmon reproduction.
- The importance of anadromous fish in transferring marine derived nutrients to upland areas and thus providing nutrients to areas that would naturally be nutrient poor.
- The lack of roads and infrastructure that make the area unique as one of the few intact ecosystems remaining in the world, and possibly unique for this type of fishery.

It would be helpful in the background section to better describe the uniqueness of the Bristol Bay watershed ecosystem in the Pacific Northwest. This would include a description of other similar ecosystems in the region that have undergone development and documentation of any changes in fish populations associated with this development. This would put the importance and uniqueness of the Bristol Bay watershed better in context.

It would also be helpful to better explain fish resources in the project area in comparison to other areas within the watershed. I understand the data may not be available and that fish population data are not available for the project area. It would be helpful to know, however, if the habitat in the project area is typical, exceptional, or inferior to that in other areas of the watershed.

Regarding geological resources, the report describes the Pebble deposit and five other mineral deposits in the Nushagak and Kvichak watersheds. It would be helpful to know if there are other mineral resources or oil and gas resources in the Bristol Bay watershed as a whole that could also be exploited. It would also be helpful to describe the portion of the watershed that is off limits to development due to park and protected area status vs. those lands that are open to mineral development.

Steve Buckley, M.S., CPG

The background information presented in the characterization of the ecologic, hydrologic and geologic resources is overly broad in scope. Specifically, the descriptions of the relationship between landforms, streams and surface water and the interaction with groundwater are mentioned as very important to fish in the watersheds, yet there is insufficient detail to assess these interactions and consequently the characterization of these resources is weak. There is more detailed information available in the Environmental Baseline Document (EBD) regarding the relation between landforms, streams, groundwater and fish habitat in the watershed.

Courtney Carothers, Ph.D.

The background information presented on the ecological and geological resources of the Nushagak and Kvichak watersheds appears to be appropriate and accurate. The report notes that there is a lack of quantitative data on salmonid populations in this region, a lack of a full identification and characterization of salmon presence, spawning, and rearing areas, and a lack of detailed understanding of how local stream and river system features (e.g., temperature, habitat structure, predator-prey relationships, limiting factors) affect salmonid production in the region. Further, climate change is noted to be affecting local conditions. These unknowns are important to stress throughout the report.

The cultural characterization presented in Appendix D presents detailed information on historical and contemporary Yup'ik and Dena'ina communities of this region, stressing the centrality of salmon and subsistence in these cultures. This assessment benefits from the time-depth of relationships developed by Boraas and Knott. Overall, this section of the report is based on standard ethnographic methods, although the research design and analysis could be explained in more detail (and described in a separate methods section). The "voices of the people" sections are helpful to present directly the perspectives given by local people. These quotes reveal the complexity of subsistence and contemporary village concerns in this region. At times, the cultural assessment can minimize this complexity.

As detailed in the specific comments below, potential risks and impacts to subsistence are framed at times in the report as primarily ones of physical health and economic factors. Subsistence harvesting, processing, sharing, and consuming are described as healthy practices for psychological, social, emotional, and cultural well-being. The subsistence lifestyle is considered healthy compared to other lifestyles. This is particularly important to note for indigenous communities, many of which are still coping with effects of colonialism, including high rates of suicide, abuse, and drug and alcohol addiction. This point is made in Appendix D (but at times could also be strengthened there, as suggested below), and is articulated in some of the quoted interview material.

Recent data on subsistence harvests and use areas collected by Braund and Associates for the PLP Environmental Baseline Document, as well as the Alaska Department of Fish and Game (e.g., Fall et al. 2012) would be a useful addition to the cultural characterization. Other studies of local traditional ecological knowledge (e.g., Kenner 2005) may help to supplement the assessment of the abundance and distribution of fish species in this region, or to supply information on other less-studied freshwater fishes. Recent research on the contemporary salmon-based livelihoods of the region (e.g., Holen 2009a, 2009b, and 2011; Hebert 2008; Donkersloot 2005) would also be helpful to include.

Appendix E also characterized the economic baseline of the region. Why is this dimension not asked about here?

Dennis D. Dauble, Ph.D.

As noted in the approach, characterization of and risk to ecological resources emphasized salmon and other important sport and commercial fish species. Consequently, the description of non-salmonid species generally lacked estimates of population size, except for sport and subsistence catch statistics. There was a long list of other resident fish in Appendix A, but their role in the Bristol Bay (and Nushagak and Kvichak) watersheds is not described in any detail there or in the main report. Another limitation to the salmon-centric assessment is that risk assessment endpoints described in Chapter 3 of the main report do not address other aquatic ecological resources. Consequently, while there was acknowledgment of ecological dependencies among salmon, other fishes, and land mammals, very little information was provided on primary and secondary production processes. For example, the relative importance of marine-derived nutrients (MDN) in the form of salmon eggs and carcasses is discussed, but there is only brief mention of aquatic insects in the diet salmonid species. A description of major groups of aquatic invertebrates, in terms of biomass and seasonal abundance, should be included. Also, what nutrient levels occur with and without MDN?

More detail on river and lake limnology would be helpful. For example, the hydrology of the watershed is mainly limited to a brief discussion of salmonid habitats. The geology of the basin emphasizes geology of mining areas and mineral processes. This seems inadequate given the importance of geology to surface water processes and groundwater movement. The report would benefit from having a summary table listing the lake size/volume and river length/discharge for watersheds potentially affected (and not affected) by mining activities.

Also missing were specific habitat requirements for rearing of juvenile salmon. A brief description of where pink and chum salmon spawn and rear in the Bristol Bay watershed relative to other salmon species should be included.

Gordon H. Reeves, Ph.D.

The assessment, which included the report and appendices, was comprehensive and thorough regarding the ecological resources of the Nushagak and Kvichack watersheds. The best available data on fish numbers and distribution (Alaska Dept. of Fish and Games aerial escapement counts, records from the Anadromous Waters Catalog and Alaska Freshwater Fish Inventory, and the Environmental Baseline Document of the Pebble Limited Partnership (2011)) were used for the assessment. These data formed the foundation for much of the assessment on potential impacts to anadromous salmonids and their freshwater habitat in these watersheds and their characterization appeared to be accurate. The authors also appeared to have thoroughly identified and considered all of the appropriate literature.

I am not familiar with data available for the other resources and am thus unable to assess their appropriateness.

Charles Wesley Slaughter, Ph.D.

If only Volume 1 – the Main Report – is considered, the characterization of some aspects of the Nushagak and Kvichak watersheds would have to be termed cursory. Chapter 2, Volume 1 (Characterization of current condition) provides only a superficial overview of the landscape of the Bristol Bay watersheds; a reader would preferably have access to Wahrhaftig (1965) or Selkregg (1976), as only two (relatively dated) suggestions, to gain a more comprehensive understanding of the region. Similarly, Volume 1 provides a relatively superficial discussion of non-fish wildlife concerns, or human/cultural concerns

By contrast, the information provided in Appendices A-H appears to be comprehensive and complete for each subject field. (Appendix I appears to be a general "template" summary, not tailored to the Bristol Bay watershed environment).

As noted in the Executive Summary, the Assessment does NOT address several major components of the (hypothetical) Pebble project, including electrical generation and transmission, a deep-water port, or "secondary development" and associated infrastructure, which would follow an initial mining project. A truly comprehensive analysis should incorporate full analysis of these aspects.

John D. Stednick, Ph.D.

The site characterization can be expanded. The team needs to better characterize the physical setting. The salmon populations and habitat linkage could also be expanded. The linkages to indigenous peoples are illustrated in Figure 3-2E, but more text would be welcomed. There are a variety of data sources that can be mined for data to better describe the physical setting. It would be useful to see geology, geomorphology, soils, vegetation, digital elevation maps, hypsometric curves of the watersheds in question, streamflow data, precipitation data—especially storm events, and water quality data for surface and groundwater over time and space.

The assessment concludes that a hydrologic modification will have detrimental salmon habitat consequences. The groundwater contributions to streamflows are important, both hydrologically and ecologically. Additional streamflow data presentation would be useful. Similarly, additional water quality data over time and space, including water hardness for metal standards, would be helpful. Additional data would be useful to better illustrate the groundwater upwelling and hyporheic exchanges. Depth to groundwater as related to streamflow, age dating of waters, streamflow modeling would all be useful.

Site disturbance will be significant, yet no discussion of soil erosion. Soil erosion and subsequent suspended sediment transport would have the potential to have significant effects on water quality, channel delivery efficiency, salmon, salmon habitat, and metal transport. There is a generic discussion of road construction related to erosion, but road standards, road location, road usage, road maintenance (salting, grading, or watering), and length of the roads would help in the risk assessment. Again, specific mine plans are not available yet, but best professional judgment?

Are any endangered or threatened species present, either state or federally listed?

Roy A. Stein, Ph.D.

Overall Characterization. The characterization of the resources of the Nushagak and Kvichak watersheds was appropriate and accurate in the ecological arena save for the issues discussed below. Geological and cultural resources seemed adequately characterized but they are not within my expertise.

Broad Scale Comments:

Global Climate Change I. Risks to salmonids seem far greater than what is reviewed throughout this portion of the document. Missing, in my view, is any consideration of Global Climate Change, especially in light of the expected life of the mine (25-78 years), applied directly to the Bristol Bay Watershed (save for a brief mention on page 5-28, 2nd full paragraph). Given our current understanding, general changes likely include more intense precipitation events and increased temperature (and then of course, all that follows from these two changes). With more intense storms come a greater likelihood of a failure of Tailings Storage Facilities (i.e., commensurate with more frequent and more intense flooding), more acidity from Pre-Tertiary waste rock (which will enter quite vulnerable, poorly buffered streams), and greater sediment influx into streams (and increasing fines in the gravel by as little as 5%, quite a small proportion, "…causes unacceptable effects on salmonid reproduction" (page 8-6; also see Chapter 7), which could occur during "routine operations", especially in light of the fact that sediment influx into streams is a cumulative process). Increased stream temperatures, depending on the absolute increase over a period of 78 years (and beyond, see "in perpetuity" comments below), could lead to reductions in salmon spawning success, as extant populations are specifically adapted to the current temperature regime. As is apparent, both increasing intensity of storms and increasing temperature will likely compromise salmon spawning success, and growth and survival of their offspring in the freshwater environment of Nushagak and Kvichak rivers.

Global Climate Change II. Indeed, climate change is affecting Alaskan salmon as demonstrated (in a paper that just appeared online July 11, 2012) by a loss of a late-migrating population of pink salmon in a small stream near Juneau, in favor of an early-migrating one. Genetic evidence supports this explanation for Kovach et al. (2012) had 17 generations of data (since 1979) showing the reduction of the September spawners in favor of the late-August ones in response to increasing stream temperatures. As Kovach et al. (2012) write in their concluding paragraph:

> "We no longer observe the clear phenotypic distinction between early- and late-migrating individuals that was once present in the system. Apparently, the very-late-migrating phenotype has been greatly reduced or potentially lost. Although

> microevolution may have allowed this population to successfully track environmental change, it may have come at the cost of a decrease of within-population biocomplexity—the loss of the late run. This is not a surprising result; by definition, directional selection will decrease genetic variation. However, it does highlight the importance of maintaining sufficient genetic and phenotypic variation within populations in order for them to have the ability to respond to environmental change."

The ramifications of this work are obvious. As pointed out in the report (pages ES-8, 2-22, 5-28 as just a few examples), the exceptional quality of the Bristol Bay salmon stocks depend on the pristine quality of a set of quite diverse aquatic habitats, which has led to the development of genetically diverse stocks of salmon within species, each uniquely adapted to particular habitats. Reducing this variability by mining on top of the rivers that produce >50% of the wild sockeye salmon in Bristol Bay serves to reduce the flexibility with which these stocks respond to any environmental change (most notably Global Climate Change), and most notably during the time course of the Pebble Mine.

Groundwater Exchange. One of the key aspects of this system is the importance of groundwater exchange with surface streams and this groundwater contributes mightily to salmonid egg incubation success and survival (page 2-21). Simultaneous with this is the fact that the water demands of the proposed mine will require more than just surface waters available to it but rather the mine will have to exploit groundwater resources to support its operations. This is yet another risk to salmonid success for reduction in the availability of groundwater and will lead to increased temperatures in summer (see pages 3-7, 5-28, 5-29) and less inviting overwinter habitats (pages 5-20, 5-29), further exacerbating both mining and climate change effects.

"In Perpetuity". Following up on the idea of increased risk (see previous points) to salmon, I struggled with the idea of this mine being monitored and maintained "in perpetuity" (e.g., pages ES-2, 4-32, 4-34). First, this relates directly to the Global Climate Change issues, in that these changes likely will continue to build through time, further exacerbating negative impacts on salmon. Even without climate change, salmon are in peril from mining operations in the Nushagak and Kvichak rivers; with climate change, the cards are stacked against them.

Second, what regulatory or institutional mechanisms currently available place the responsibility of these efforts on the corporation "in perpetuity"? Because mining companies come and go, might there be mechanisms that come into play if this particular company goes bankrupt? Might there be some sort of bonding process that protects the environment from the mine's remains into the long-term future? If not, should new legislation be pursued?

Third, I began the review process with idea that the mine would be built, would capture its resources, and then would end by restoring the site. The scenario that includes monitoring and maintenance 1,000 years into the future continues to bother me. One solution that comes to mind is that the federal or state government would be charged with these monitoring and long-term maintenance activities, paid for by a hefty tax on the minerals removed from this site.

Finally, I am not encouraged by any of the text surrounding this issue, the two most relevant quotes (pages 4-31 and 5-45, respectively) being:

> "There are no examples of such successful, long-term collection and treatment systems for mines, because these time periods (100's to 1000's of year) exceed the lifespan of most past large-scale mining activities, as well as most human institutions."

> "We know of no precedent for the long-term management of water quality and quantity on this scale at an inactive mine."

And, finally, a quote from Chapter 8 on page 8-13:

> "The promises of today's mine developers may not be carried through by future generations of operators whose sole obligation is to the shareholders of their time (Blight 2010)."

William A. Stubblefield, Ph.D.

The EPA's assessment document presents a seemingly comprehensive compilation of the data associated with the ecological, geological, economic, and cultural resources of the Bristol Bay area. The characterization as presented seems to provide appropriate background information for the assessment considering the hypothetical nature of the evaluation. Without having specific knowledge of the area in question it is not possible to provide an assessment as to whether the characterization was accurate. I'm unaware of significant literature, reports, or data that were specific to the site and would be useful for consideration.

Dirk van Zyl, Ph.D., P.E.

Of the information provided in the EPA Assessment, I can only comment on the geological information. This information was taken from documents that were prepared conforming to and in compliance with the standards set out in National Instrument 43-101 (NI 43-101) (Ghaffari, et al, 2011). This regulatory instrument emphasizes resource information for projects. While I cannot comment on the accuracy of the regional geological information, the document should reflect accurate geological information of the Pebble District as known at the time when the report was prepared.

I cannot comment on any other significant literature, reports, or data missed that would be useful to complete the characterization.

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment presents a well-documented discussion of the fish and wildlife resources of the Bristol Bay region, including information more specific to the Nushagak River and Kvichak River Watersheds. The document contains a thorough discussion of the interactions among species, including nutrient flows and the importance of groundwater systems. The information is, however, general in nature. Should mine development go forward, it will be necessary to obtain ecological information specific to the potentially affected areas. The information should include timing of fish spawning, egg hatch, in-migration and out-migration and similar specific life-history information for important wildlife species.

The discussion on the cultural resources is outside my areas of expertise and I cannot provide meaningful comments.

Paul Whitney, Ph.D.

There are several places in the text where the loss and degradation of habitat on fish populations could not be quantified because of the lack of demographic data for salmonids (e.g., page ES-26, third bullet). This statement is only partially accurate. It is true that population models such as life tables or Leslie Matrices require population age class data to estimate population numbers. However, even if demographic data are available, these population models do not relate population estimates to habitat quality. Incomplete data and relating fish population estimates to habitat quality is not an uncommon problem in ecology and there are many approaches for dealing with this issue. Approaches such as Ecosystem Diagnosis and Treatment (McElhany et al. 2010), Expert Panels (Marcot et al. 2012) or Weighing Lines of Evidence (see Section 6.1.5) are methods for relating habitat quality to fish abundance. Models, of course, bring their own uncertainties but it seems better to have quantitative estimates (and discussion of the estimates) of all the potential fish losses due to habitat loss than no estimate at all.

Even though the Executive Summary indicates that the loss and degradation of habitat on fish populations could not be quantified, the text does provide such estimates. The assessment (page 6-11, first full para) estimates "that the combined effects of direct losses of habitat in the North Fork Koktuli, down stream in the mainstem Koktli and beyond, and impacts on macroinvertebrate prey for salmon could adversely affect 30 to 50% of Chinook salmon returning to spawn in the Nushagak River watershed." This type statement and the basis for the statement followed by a discussion of uncertainty is a good example of the estimates that would better describe possible impacts of the example mine on salmonids. Another example estimate appears on page 6-39 for four species of salmon.

Question 2. A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?

David A. Atkins, M.S.

This is a world class deposit with nearly 11 billion tonnes of total resource. It is unlikely that all the ore currently identified will be mined, so 11 billion tonnes would be an upper bound. It is also certain that the mine would have to be large to justify the capital investment to build infrastructure in such a remote area. The question then becomes what size mine is feasible from a technical and economic point of view.

The mine plan as presented is based on a "Preliminary Assessment Technical Report" prepared for Northern Dynasty Minerals by Wardrop (Ghaffari et al. 2011), in conformance with Canadian National Instrument 43-101, which is used to set standards for public disclosure of scientific and technical information about mineral projects of companies on bourses supervised by the Canadian Securities Administrators. The report outlines three scenarios:

- An "investment decision case" for a 25-year mine life that would mine 2 billion tonnes of ore;
- A "reference case" for a 45-year mine life that would mine 3.8 billion tonnes of ore;
- A "resource case" for a 78-year mine life that would mine 6.5 billion tonnes of ore, or 55% of the total measured, indicated and inferred resource.

The Assessment chose minimum and maximum mine sizes of 2 billion and 6.5 billion tonnes of ore, respectively. Thus, the resource estimate used for the Assessment is the same as that presented in Ghaffari et al. 2011, and thus realistic and sufficient.

Pebble West is a low-grade deposit near the surface that would most efficiently be mined using open-pit methods, while the Pebble East deposit is a deeper, higher-grade deposit that would most-efficiently be mined using underground methods (specifically block-caving). Mine facilities would include:

- Open-pit mining utilizing conventional drill, blast, and truck-haul methods for near-surface deposits
- Underground, block-cave methods for deeper deposits
- A process plant with throughput of 200,000 tonnes/day that utilizes conventional crush-grid-float technology with secondary gold recovery
- Other mine-site facilities, including:
    - Tailings storage
    - Waste rock storage (the estimated waste/ore strip ratio is 2:1)
    - A natural-gas fired power plant
    - Shop, office, and camp buildings

- Pipelines to ship ore concentrate slurry to the port facility; return water from the tailings slurry after separation at the port facility; and fuel.

This mining and ore processing approach is both modern and conventional, and the Assessment follows this approach. Therefore, the mine scenario is reasonable as a general basis for the Assessment.

The Pebble Partnership may present an alternative to this plan that could vary or alter how the mine is developed, but the fundamental components would most likely remain the same.

Steve Buckley, M.S., CPG

Additional mine scenarios are necessary to appropriately bound the magnitude of potential mine activities. The maximum mine size in the mine scenario seems appropriate given the existing public information on the Pebble deposit. The minimum mine size of 2 billion tons exceeds the 90th percentile of global porphyry copper deposits. Using a minimum mine scenario in the range of 250 million tons, or in the 50th percentile range of global porphyry copper deposits, would be more appropriate to bound the lower end of the magnitude of potential mine activities. It would also be useful to include some variation in mining methods. This could include incremental development of a smaller open pit in the lower grade zones of a deposit, along with a portion of the higher grade deposit being mined by underground block caving methods to further assess the minimum potential impact of the mine scenario.

Courtney Carothers, Ph.D.

The hypothetical mine scenario was closely based on a probable mine prospect under development. As such it appears to be realistic and sufficient, if challenging to conceptualize as fully hypothetical given this association.

The report notes that the Pebble deposit may exceed 11 billion metric tons (4-17). The rationale for choosing 6.5 billion metric tons as a maximum size is based "most likely mine to be developed (4-19)." The rationale for not choosing a higher potential maximum could be explained.

Dennis D. Dauble, Ph.D.

The hypothetical mine scenario appears realistic and useful in terms of potential project scope. Referenced literature provides appropriate context, however, I can't help believe that information on environmental impacts from past mining activities conducted in the Rocky Mountain metal belt would be relevant to this assessment in some cases. It's also possible that recent published information from Holden Mine in northern Washington State would help establish context for effects of leachates and model results that predict downstream transport of tailing material, for example.

Gordon H. Reeves, Ph.D.

I am not familiar with this subject area and unable to comment on the how realistic or sufficient the hypothetical mine scenario was.

Charles Wesley Slaughter, Ph.D.

Given the available information base for the ore deposits of the Bristol Bay watershed, and the publicity which has attended the Pebble planned development over the past several years, the Assessment's hypothetical mine scenario seems fairly realistic. Further, it is appropriate that the Assessment consider the probable impacts of other future mineral development projects once an initial entry (presumably Pebble – Northern Dynasty Minerals) has been accomplished. Such subsequent development – "cumulative effects over a long time period" -- could (and should) receive **more** emphasis than is accorded in the Assessment.

John D. Stednick, Ph.D.

The approach seems reasonable. Perhaps a review or compilation of the various porphyry complex mines and their location would be useful? The physical setting in Southwest Alaska is not the same as Bingham Mine in Salt Lake City. The Fraser River was selected because of the significant salmon resource, but that resource has been adversely affected by the upstream mining operations.

Roy A. Stein, Ph.D.

Hypothetical Mine Scenario. Though mining does not lie within my area of expertise, I thought that this scenario helped me understand the potential impact of a mine of this magnitude in a wilderness, pristine watershed. I find it difficult to comment as to whether this scenario is realistic and sufficient, though I did use this scenario to guide my comments below.

Minimum and Maximum Mine Size. For me, as an ecologist, this bounding helped me understand the potential impacts of the Pebble Mine, though I did not understand just what the probability of either mine size happening in the near term. Is it more likely that the initial Pebble Mine will be maximum or minimum in size? Some reflection on these probabilities would have helped me interpret the ERA with some additional insight.

One Watershed. Given the productivity re salmon from these two river systems (50% of the sockeye salmon in Bristol Bay are produced from these rivers), might there be some thought given to limiting the mining operations to a single watershed, either the Nushagak or the Kvichak (p ES-2)? In so doing, in a single stroke, the impact of this mine on salmon is reduced by 50% or more. Could the Pebble Mine be confined to one watershed, such as where the majority now falls—in the Nushagak River (both the north and south forks of the Koktull River) watershed? Even so, this suggestion becomes especially pertinent to Chinook salmon spawning in the Nushagak River, for this run is "near the world's largest" (page ES-5) but yet the Nushagak Watershed is small relative to other watersheds (such as the Kuskokwim and the Yukon) where Chinook salmon are abundant. As a result, any impacts to the watershed by a mine of this size are magnified, another concern when considering this location. Without mining expertise, I cannot judge whether it would be possible to mine in only one of the watersheds, rather than both. Even so, some consideration should be given to this suggestion.

William A. Stubblefield, Ph.D.

The hypothetical mine scenario proposed in the document seemed plausible; however, the evaluation of the proposed mine is outside my area of expertise and I can provide no judgment regarding its potential realism.

Dirk van Zyl, Ph.D., P.E.

The hypothetical mine scenario adopted by the EPA relied almost exclusively on the document prepared for Northern Dynasty Minerals (NDM), one of the partners of the Pebble Limited Partnership. Developing a mine plan for a specific ore body is a large task and is undertaken by a large team of engineers and scientists. In the process of developing a mine plan many options are considered for each facility and its components, including mining methods, process design options, waste rock management options, tailings management options, shipment of product, etc. The hypothetical mine scenario was prepared by an independent consulting company for one of the partners and this plan does not necessarily represent the design and management options that will be selected for developing this ore body. Because of ore grades and the deposit style, it is most likely that an open pit mine will be developed as assumed in the report, however the size of the ore body and the strip ratio are completely dependent on metal prices and production costs at the time of mine development. While some of the components of the final mine may contain elements of the conceptual mine, it is impossible to know whether the hypothetical mine scenario is realistic as will be further discussed in the comments below.

To address the issue of sufficiency it is necessary to understand the range of potential outcomes related to the various options. For the most part, the EPA study used the information from the NDM document for evaluating impacts to salmonids. Using different options for some or many of the facilities could result in impacts that are different from those described in the report. I would therefore suggest that using only the hypothetical mine scenarios is insufficient. There could be a range of impacts, such as the surface areas of facilities, which in some cases could be smaller than what was chosen and in other cases larger. However, this does not mean that the hypothetical mine represents "average conditions." I therefore consider the mine scenario not sufficient for the assessment.

The minimum and maximum mine sizes selected by EPA are 2 billion tonnes mined over 25 years and 6.5 billion tonnes mined over 78 years, in both cases the daily ore processing rate is 200,000 tonnes. As indicated above, the final economic mine size at the time of development will be determined by metal prices and production costs. Note that production costs, as used here, include all the considerations related to regulatory, environmental and social aspects of the mine and its environs. Mining companies typically make investment decisions for periods of 20 to 30 years. It is seldom, if ever, that a new investment will be made based on a 78 year mine life, however the upside potential will be taken into account when an investment for a shorter mine life is made. It is also unlikely that environmental regulatory agencies will consider issuing a permit, including closure plans, etc. for a 78-year project. Furthermore, even if the mine ultimately continues for 78 years, it is certain that the operating and environmental control technologies and societal expectations will change in that period and therefore the elements used by EPA for the maximum size hypothetical mine will certainly not be valid for such a long mine life. It is therefore my conclusion that assuming the development of a 2 billion tonne ore body is realistic but that assuming development of a 6.8 billion tonne ore body is not.

The EPA assessment report includes a range of the literature and reports in evaluating the selected mine scenario. However, I have a number of specific comments about various aspects of the report as well as the references.

Good practice vs. best practice. On p. 4-1 of the report the EPA states: "Described mining practices and our mine scenarios reflect the current practice for porphyry copper mining around the world, and represent current good, but not necessarily best, mining practices". EPA does not clarify this decision, nor does the report clarify the distinction between "good" and "best" practices. It can only be concluded that "best" will be better than "good". On the basis of this, it is inconceivable to me that the Bristol Bay communities, the Alaska regulatory authorities as well as Federal Regulatory Authorities will not demand that the company follow best mining practices. It is also inconceivable to me that the company will not follow best mining practices in the design and development of such a mine. During the engagement processes all the stakeholders will have to agree what represents "best" practice in the design of the mining project. It is important to note that most of the failure statistics used as a basis for the evaluations in the report are derived from data gathered over the last 50 years or so (e.g. refer to p. 4-45 of report). It may be argued that this information is mostly for mines following "good" practices and in many cases for projects that had a lower standard of care. To my knowledge there are no statistics available that compare failure rates of facilities designed and operated under "good" practice to those designed and operated under "best" practices.

Mine scenarios. The executive summary indicates (p. ES-11): "The mine scenario includes minimum and maximum mine sizes, based on the amount of ore processed (2 billion metric tons vs. 6.5 billion metric tons), and approximately corresponding mine life spans of 25 to 78 years, respectively". This seems to indicate that the mine life cycle in the first case consists of 25 years operational life followed by closure and similarly for the second case 78 years of operational life followed by closure. However, a careful review of the water management section (section 4.3.7) indicates that this is not the case. The EPA water balance calculations are simplified to a set of deterministic values in Table 4-5 for four water management stages during the overall mine life cycle: start-up, operations minimum mine (25 years), operations maximum mine (78 years), and post-closure. For post-closure, only the 78-year mine life numbers are used. It therefore seems that EPA is not considering that the 25-year mine will close, but that its life will automatically be extended to 78 years. Does this mean that the EPA really does not evaluate the minimum mine size completely, i.e. the 25-year mine life followed by closure? It is important that this be clarified as it would be inconsistent not to evaluate closure of the 25-year mine. Additional evaluations will be required.

Tailings management technologies. Ongoing technology development has resulted in a broader range of tailings management options than only slurry tailings disposal. Filtered dry stack tailings can be considered as a realistic option, even for mines with higher production rates. Flotation of remaining sulfides in the tailings before deposition is also a realistic option for mines. While these technologies are mentioned, they are not selected for reasons such as technology not appropriate for the climatic conditions and concerns with disposal of pyrite waste. Both of these are not insurmountable technical issues and adopting such management options will reduce failure probabilities and potential impacts following a failure. The impacts of these other tailings management options will definitely be far smaller than those for the selected mine scenario using slurry tailings disposal.

Waste rock management. The waste rock management plan on p. 4-13 calls for the potentially acid generating (PAG) waste rock to be separated from the rest of the waste rock and that the

"PAG waste rock might be placed in the open pit at closure to minimize oxidation of sulfide minerals and generation of acid drainage". However, on p. 4-33 it is stated that: "PAG waste rock will be processed through the flotation mill prior to mine closure, with tailings placed into the TSF (tailings storage facility) or the mine pit." These two alternatives represent completely different management, economic and environmental conditions and are not consistent. Milling the PAG waste rock represents a higher cost than placing the PAG rock in the pit and placing the PAG waste rock tailings in the TSF will increase the size of the TSF. Placing the PAG tailings in the pit will set up a completely different management scenario than placing the PAG waste rock in the pit. This clearly has to be clarified.

Water balance and management – waste rock. Mine site water balance and management is a very complex issue as recognized by the EPA on p. 4-27: "..water balance development is challenging and requires a number of assumptions". Because of these uncertainties, complex probabilistic dynamic models are employed at mines where the site details are better defined than that of the EPA hypothetical mine scenario. The information in Box 4-2 indicates that the "captured flows include water captured at the mine site and the TSFs (Table 4-5). The total amount of water captured at the mine site includes net precipitation (precipitation minus evapotranspiration[1]) over the areas of the mine pit, the waste rock piles, and the cone of depression (without double-counting any areas of overlap)". On p. 4-23 it is stated that: "Monitoring and recovery wells and seepage cut-off walls would be placed downstream of the piles to manage seepage, with seepage directed either into the mine pit or collection ponds". Figure 4-9 shows this schematically where leachate from the waste rock enters the groundwater that then flows to the mine pit or to the monitoring and collection well. If net precipitation only includes the components above without infiltration and if this net precipitation is captured from that waste rock pile (as stated in Box 4-2) then there should not be any water available to infiltrate into the waste rock pile, i.e. there should not be any leachate. The approach that is used in the water balance is inconsistent with field performance and the literature as is it difficult to imagine a case where there is zero infiltration into a porous waste rock pile (e.g. Nichol, et al, 2005 and Fretz, et al, 2011) This must be clarified and the evaluations should reflect <u>realistic</u> conditions.

Dam failure – tailings storage facilities. During operations "water falling within the perimeter of a TSF would be captured directly in the TSF, but runoff from catchment areas up-gradient of the TSF would be diverted downstream" (p. 4-27). At closure water would be removed from the TSF providing more storage but also maintaining a small pool to "keep the core of the tailings hydrated and isolated from oxidation" (p. 4-32). This seems to assume that the diversion systems will be kept in place and most likely will be upgraded to divert up-gradient surface water around the tailings impoundment. It is likely that the design criterion for the upgraded diversion system will be the probable maximum flood (PMF) as is done at a number of mines. Dam failure analyses were done assuming that the flood leaving the TSF includes the PMF inflow from the up-gradient catchment, excess water on top of the tailings and 20% of the tailings volume (Box 4-8). While one can argue that a failure including all these materials may be a plausible, although very low likelihood, event during operations, it seems less probable that such a failure

[1] During operations most of these areas will not be covered with vegetation and the correct terminology here is "evaporation". The correct terminology is used on p 6-37.

will take place for the mine closure period when an upgraded diversion system is in place. Also, during the closure phase the tailings will consolidate and be less mobile. Note that the densification behavior of oil sand tailings referred to on p. 4-32 (i.e. the Wells, 2011 reference) does not apply to copper tailings. The presence of clay minerals and bitumen in the oil sand tailings is the source of the different behavior (Znidarčić, et al, 2011).

Reclamation slope of waste rock. On p. 4-32 it is stated that: "We assume that NAG waste rock would be sloped to a stable angle (less than 15%) (Blight and Fourie 2003)". I contacted the Profs. Geoff Blight and Andy Fourie about this statement and received the following response from Prof. Blight: "The only reference to 15 degrees (not 15 %) slopes is the following, talking about the outer tailings, not waste rock covered, slopes of decommissioned TSF's: "it must be remembered that the outer slopes will need to be rehabilitated, and that for vegetation to be stable, and surface erosion minimal, the maximum outer slope should not exceed 15 degrees." I might add that a 15% slope is at an angle of 8.5 degrees." This oversight must be corrected and more typical closure slopes of about 30% (or 3H:1V, about 18 degrees) for waste rock should be used in the evaluations.

Phyllis K. Weber Scannell, Ph.D.

The Environmental Assessment discusses a hypothetical mine (given that mine plans have not been developed). Page 4-5 of the document states that "rocks associated with porphyry copper deposits tend to straddle the boundary between net acidic and net alkaline . . ." The Pebble Project Environmental Baseline Report (SRK 2011, Chapter 11) summarizes testing on the samples from the pre-Tertiary porphyry mineralized rock in Pebble East Zone (PEZ) and Pebble West Zone (PWZ). The metals leaching/acid rock drainage study showed acidic conditions occurring immediately in core with low NP, but the average delay to onset of acidic conditions was estimated to be about 20 years. Copper was leached in the highest concentrations, but Co, Cd, Ni and Zn also leached from samples from PEZ. Wacke (sedimentary rock) samples from PEZ and PWZ leached As, Sb and Mo in addition to Cu. (SRK, page 58). The available information on acid generation and metals leaching appears to be preliminary. Development and permitting of a viable mine plan will require extensive sampling and data analysis of ore samples, plans for classifying waste rock (as PAG and NAG), and, possibly, plans for collecting and treating runoff and seepage waters. The Environmental Assessment seems a bit premature in making an assessment of the potential for ARD or ML.

Recommendation: This section of the Environmental Assessment should be revised as more data on ARD and ML become available.

Paul Whitney, Ph.D.

Reclamation Plan. I am not familiar with the Northern Dynasty Minerals mine plan. I wonder if their mine plan includes a Reclamation Plan? If not, why not? If their mine plan includes a Reclamation Plan, why isn't it presented as part of the Bristol Bay Assessment? The feasibility of reclaiming the waste rock and tailings areas and possibility the pit (page 4-23, last para, last sentence) seems important for evaluating the acceptability of any proposed mine. I am not aware of any mine regulating agency that does not require a Reclamation Plan as part of a mine application. I wonder if placing waste rock and tailings back in the pit and reducing surface infiltration would greatly reduce the need for water treatment.

Best Mining Practices. The assessment refers to the example mine plan as having both the "best" mining practices (e.g., page ES-10, five lines from the bottom) and "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). Both of these statements can't be accurate.

Noise Levels. The mine plan should provide information on the location, frequency and size of blasting, sound level isopleths around the mine, and efforts to minimize sound levels as the mine develops. I wonder if a majority of the sound levels will attenuate as mining activities move deeper into the ground or will there be a hundred years of blasting at the surface level. The interviews with the villagers indicate that blasting and helicopter noise is a concern (Appendix D, Cultural Characterization, page 94). A characterization of current noise levels in relation to the area and timing of current and past wildlife use would help to determine if the whole or parts of the watersheds are less than pristine.

Water treatment during the winter. I wonder if it will be possible to treat water during the winter. Will such treatment have to occur in a warm building? If so, what are the temperature consequences of releasing warm water into streams?

Cone of Depression. I have worked on pit mines where hydrogeologists model the lateral extent of the cone of depression and have mapped the lateral extent as an area around the pit. The lateral extent of the cone of depression illustrated in Figure 4-9 appears to be underestimated and has no effect on streams or wetlands. The figure has no scale. Is the lateral extent of the cone of depression in Figure 4-9 based on modeling (see Box 4-2, para 3, last sentence)? If so, how many NWI wetlands and meters of stream are in the area used for the model? If there are wetlands or streams in the modeled area, how far down stream will the cone of depression influence stream flow?

The information in Box 4-2 doesn't clearly (at least to me) deal with the proportions of run-on and run-off water. If the diverted run-on water is supposed to mitigate the cone of depression will it be available for down stream resources? Why won't diverted water seep back into the nearby pit versus mitigating the cone of depression? The answer to these questions is on page 5-72 but merely indicating there will be a reduction is not very informative.

Gold and Heap Leach. The mine plan has many references to the value of the gold associated with the copper, the efficiency of recovering gold and the cyanidation process for recovering the gold (e.g., Table 7-1 where 9 of 11 deposit types have gold). The likelihood of gold being a part of the mining plan is obviously uncertain but to this reviewer seems high. More information on the location of a heap leach facility and transport of cyanide to the heap leach facility should be addressed. If spills of transported chemicals are likely (page 4-62, 4.4.4 Road and Culvert Failures, para 1, last sentence), they should be assessed. If concentrates in pipelines will include processed gold (page 4-61, para 1), the likelihood of cyanide being present in the pipeline concentrate needs to be addressed.

Run on and run off water terminology. I am use to referring to up gradient or adjacent water that runs onto the pit or tailings facilities as run on water and water from the mine or storage facilities as run off water. The assessment doesn't always distinguish these two types of water.

For example, page 4-13 line 6 refers to precipitation run off water as up gradient water. Page 4-26, first bullet, refers to run off water as water running off mine facilities. The terminology overlap makes it difficult (at least for me) to understand how the run on and run off water will be captured and diverted around the mine facilities or used for other purposes. In addition to calculations, diagrams of the diversions would be helpful. Will there be parallel diversion ditches around the facilities, one for run on and one for run off water? Will one or both of these ditches be lined? How will the water in these ditches be influenced by the cone of depression? These questions are alluded to in the discussion on page 4-27 , second para, but are not explicitly addressed. I am sure engineers can and have answered these questions for other mines with water balance analyses. It would be interesting to see an explicit summary of the water balance for the various facilities. Such analyses would be good for the example mine plan during operation and once the mine is no longer a net consumer of water (page 5-44, para 2). Without the water balance analyses, potential impacts are not easily understood or quantifiable.

A "protective approach" is mentioned on page 5-30, para 3, last sentence. This has something to do with water management and would be good to explain. Some ideas for how to manage and separate run on and run off water might help determine which streams might dry up and what type of mitigation measures (i.e., lining ditches) could minimize the impact. In addition, if run on water can be maintained in a diversion ditch, what is the opportunity for developing a reclamation plan for the ditches? Such plans might be able to minimize and compensate for lost reaches of headwater streams.

Question 3. EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?

David A. Atkins, M.S.

The mine will by necessity remove those streams and wetlands that are beneath the pit, waste rock, tailings, and processing plant development areas. For the 'no failure' scenario, the Assessment presents lengths of stream and areas of wetlands that would be lost due to physical displacement of the aquatic resources from mine development and reduction in flows from mine water management. The assessment presents the following resources that would be lost and that have been shown to be spawning or rearing habitat for coho, Chinook, and sockeye salmon, or have resident populations of rainbow trout and Dolly Varden:

	25-year scenario	78-year scenario
Eliminated or blocked streams (km)	87.5	141.4
Reduced flow (>20%; km)	2	10
Eliminated wetlands (km^2)	10.2	17.3

These impacts are substantial largely because of the very large nature of the project. However, it would be helpful to describe the significance of this loss, specifically with regard to the following questions:

- What impact would the loss described for streams and wetlands from project development have on the fishery within the Nushagak and Kvichak basins?
- Is this loss significant in comparison to the fishery as a whole?
- Are there local communities that could be affected by this specific loss?
- Is fragmentation of the resource from this loss a significant impact (i.e., are there stocks that are unique to the project area)?
- Can these impacts be mitigated through restoration at closure or by creating offsets in other areas that are not as productive?

Steve Buckley, M.S., CPG

The engineering and mitigation designs associated with the no-failure mode of operation are inadequate. There is no detailed discussion of engineering practices. There is insufficient discussion of any potential mitigation measures and there is a lack of any detailed research into applicable engineering and mitigation methods. Appendix I provides some engineering and mitigation practices along with water quality mitigation and monitoring during closure, however these are not discussed or accounted for in the main assessment document.

Courtney Carothers, Ph.D.

The no-failure mode of operation appears to be described adequately. The engineering and mitigation practices appear to be sufficiently detailed, reasonable, and consistent, although I have no particular expertise with which to evaluate this part of the assessment.

It would be helpful to have a clear statement about how well the local (geotechnical, hydrologic, and environmental) conditions in this region have been studied and characterized. How well are statistics from mines and TSFs constructed in very different environments likely to apply here? How much is known about how such structures behave in this particular environment?

Dennis D. Dauble, Ph.D.

The description of the no-failure mode for mine operation appears adequate in terms of potential mitigation measures that might be employed. I am not up to date with current engineering practices and subsequent risks to the environment from best-practices or operating under optimal conditions. However, it would be helpful to include a short discussion of which mitigation measures would be most applicable to mining activities in the Bristol Bay watershed.

Gordon H. Reeves, Ph.D.

This is an area outside my expertise and I am unable to evaluate and assess the adequacy of what was presented or the quality of information presented, or to identify potential missing literature.

Charles Wesley Slaughter, Ph.D.

Based on the actual history of other major resource extraction projects, in Alaska and throughout the world, a "no failure" assumption seems unrealistic. The assumption should rather be that there will be failures, of varying modes and magnitudes, over the life of the project. This reality is recognized in several sections of text.

In some sections in the Assessment, presumed "mitigation practices" are either cursory, optimistic, or so general as to be un-supported. Examples: Section 4.3.7 – Water Management – cursory, generalized statements about handling water: "Uncontrolled runoff would be eliminated…. The mine operator would capture and collect surface runoff and either direct it to a storage location…or reuse or release it after testing and any necessary treatment"; "….water from these upstream reaches would be diverted around and downstream of the mine where practicable"; "precipitation would be collected and stored…." Another example, from Chapter 6: "Assuming no water collection and treatment failures, this excess captured water would be treated to meet existing water quality standards and discharged to nearby streams, partially mitigating flow lost from eliminated or blocked upstream reaches."

John D. Stednick, Ph.D.

The no-failure mode is adequately described. The proposed mine location and characterization is tentative, but can be used to illustrate the risk assessment. The mine footprint will disrupt/disturb contributing watershed and wetland areas, resulting in hydrologic modification. The hydrologic modification in a groundwater influenced streams will affect quantity and quality of salmonid habitats, particularly in low flow conditions.

Pollutant/toxicity assessment focused on copper. Other metals can be presented to show the range of metal concentrations for chronic and acute toxicity.

The discussion of roads is mostly related to fish blockage and soil erosion. Are road locations known?

There are no engineering and mitigation practices described in this section.

Roy A. Stein, Ph.D.

No Failure Operations and Their Impact. What about the failure of continued monitoring, of continual inspection, of continual, rigorous oversight? This is more insidious than a catastrophic failure of some sort, but perhaps just as dangerous. How can we be sure that mine operators will be held strictly accountable for their actions with regard to best practices, meeting all the various and sundry regulations, and communicating all of these activities back to the regulatory organization? Will there be a force of will on the part of the EPA or other regulatory body to be sure that all activities of the operator are appropriate and within regulatory limits? The down-side of poor monitoring and lack of rigorous oversight is the loss of salmonid populations. These losses are, in my view, less important than compromising human health and life. Yet, at the Upper Big Branch Mine in West Virginia, dust standards have been exceeded for years, leading to a dust explosion that killed 29 miners on April 5, 2010. In turn, even surviving miners were not immune to these dust impacts, for they suffer from "black lung", a condition that literally shortens their life by decades. In turn, much of the monitoring of these conditions has historically been the responsibility of the owner corporation, rather than an independent regulatory body, much like "the fox guarding the chickens". Here at the Pebble Mine site, where only fish (but, of course, Native Alaskan subsistence users as well) are at stake, would one expect rigorous oversight by appropriate regulatory bodies? Skepticism leads to cynicism when contemplating the Upper Big Branch Mine case history in the context of the Pebble Mine proposal.

Engineering Practices and Mitigation. I did not think that mitigation was well described in text. My comments on mitigation issues can be found below associated with Question 12.

William A. Stubblefield, Ph.D.

It is interesting and appropriate that the EPA has included both modes of operation in conducting this assessment. This approach provides some degree of "bounding" for the assessment; however, the degree of accuracy (i.e., predictability) for either scenario cannot be known at this time. The document appropriately acknowledges that there are a variety of potential mitigating factors (e.g., acts of God, accidents, market changes) that may render the assumptions used in this assessment incorrect.

Dirk van Zyl, Ph.D., P.E.

The no-failure mode of operation failures is based on surface disturbances and potential blockages caused by the various facilities. For example, for the mine pit, TSF and waste rock facility the surface areas of these facilities are used as a basis for calculating the streams and wetlands affected by the mining activities. While the failure mode is adequately described engineering and mitigation practices are not adequately described by EPA.

The EPA Assessment states on p. 8-1 "Routine operations are defined as mine operations conducted according to conventional practices, including common mitigation measures, and that meet applicable criteria and standards". The adverse effects listed are: direct impacts as a result of removal of streams in footprint of mine pit and waste storage areas; reduced streamflow resulting from water retention; removal of wetlands in the footprint of the mine; indirect impacts of stream and wetland removal; diminished habitat quality in streams below road crossings and inhibition of salmonid movement from culverts that may block or diminish use of full stream length.

Any mine in Bristol Bay will have to undergo a rigorous and lengthy regulatory review and permitting process. I do not know of a process that will exclude consideration of the impact of all mine facilities on the streams and wetlands in the region. Therefore, I would suggest that the full implications of "mine operations conducted according to conventional practices, including common mitigation measures, and that meet applicable criteria and standard" should have been addressed in the report. The EPA (2003) document on Generic Ecological Assessment Endpoints for Ecological Risk Assessment specifically details the applicability of Section 404 of the CWA in addressing community and ecosystem-level endpoints. "The CWA provides authority for the Corps to require permit application to avoid and minimize wetlands impacts and requires EPA to develop, in coordination with the Corps, the criteria used for Section 404 decisions. When damages to wetlands are unavoidable, the Corps can require permitees to provide compensatory mitigation".

Similarly one would expect that the regulatory reviews will require that the impacts resulting from loss of streams, streamflow and road crossings will be addressed through engineering designs, proposed mitigation measures as well as regulatory and community engagement best mining practices (see discussion above).

On p. 4-33 it is stated that "Environmental impacts associated with premature closure may be more significant than those associated with planned closure, as mine facilities may not be at the end condition anticipated in the closure plan and there may be uncertainty about future reopening of the mine". Further text describes potential negative impacts from such a premature closure. One of the outcomes of the regulatory review and permitting will be the establishment of financial assurance that will provide State and Federal Regulatory Agencies with the financial resources to accommodate a closure. These obligations are typically reviewed on a 3 or 5-year interval to also make sure that they are adequate to cover premature closures. If the mining company is still managing the site then they will have responsibilities under all Federal and State Regulations and the dire picture painted by the EPA Assessment should not come to pass.

Because of this major oversight of the realities when permitting and operating a mine it is essential that the scenarios be reviewed by evaluating the effects that regulatory requirements and resulting mitigation methods would have on the no-failure conditions before completely reworking the no-failure mode of operations and their impacts. Other significant reports and data that should be reviewed include typical permitting documents and resulting requirements for similar mines in the US and Canada to obtain a range of potential outcomes. Such an evaluation will also contribute significantly to the discussions in Alaska when the Pebble Mine and other mines in Bristol Bay are brought forward to permitting.

Phyllis K. Weber Scannell, Ph.D.

Chapter 4 proves a detailed description of a hypothetical mine design for a porphyry copper deposit in the Bristol Bay watershed. Some of the assumptions appear to be somewhat inconsistent with mines in Alaska. In particular, the statement that dewatering would reduce or eliminate the flow in streams draining the site (page 4-26, 4th bulleted statement) is likely not correct. Dewatering has not resulted in measurable reductions of stream flow at other mine sites in Alaska.

The 5th bullet states that water withdrawals for mine operations would also diminish stream flows. Many mine sites recycle process water and water from the tailings pond and do not experience a substantial reduction or elimination of stream flows.

Section 4.3.8: Post-closure site management raises critically important issues: can a mine in this area be designed for closure? Is it acceptable to develop and operate a mine that will require essentially perpetual treatment? It is my belief that these are the essential questions that should be addressed during any mine permitting process.

Section 4.3.8.1 raises concerns about long term water quality and quantity from the mine pit. These concerns need to be addressed during a mine permitting process. Pit water quality depends on how the pit is developed, what reclamation will occur, if reclamation will be an on-going part of the mining process, and what kinds of water treatment will be used.

Paul Whitney, Ph.D.

Mitigation Plan. Most mine permit applications I have worked on include both mitigation to minimize environmental impact and mitigation to compensate for environmental impact. The assessment outlines a variety of mitigation measures to minimize impact but no compensatory mitigation. This is a concern; for, I wonder if compensatory mitigation for the proposed mine is even possible in the watersheds.

The watersheds are characterized with descriptors as "pristine" (e.g., page 6-29, last para, second line), "nearly pristine" (e.g., pages 2-25 and 7-2) and "exceptional quality" (page 2-20) and that the return of the salmon "fuel" (i.e., provide energy to) the terrestrial food web. If in fact the watersheds are pristine or nearly pristine, the habitat is high quality and there is little if any opportunity for compensatory mitigation (i.e., improving low quality habitat) in the terrestrial and fresh water environments.

I agree that the ecological resources can be ranked as having high quality, but from an energetics and food web perspective, the pristine characterization may not be accurate. The commercial catch of approximately 27.5 million fish each year (up to 70% of the total number of sockeye produced) is a lot of calories that are not entering the ecological foodwebs of the watersheds. Granted some of the commercial catch (if not caught) might not enter the watersheds, but some and perhaps a lot would, especially in good run years. While the harvest level might be sustainable, the loss of this amount of energy causes pause to characterize the watersheds as pristine or nearly pristine. The potential impact of fisheries on energy flow has been addressed by Pauly et al. (2000) and Libralato et al. (2008). I wonder if it is technically possible that a reduction in the commercial fishery is a compensatory mitigation measure.

Effluent treatment. Water quality information in the assessment for benchmarks, background, and leachate is extensive. A thorough review of the water quality and toxicity information is way beyond the scope of work that I signed up for. After several reads of this information, it appears that the work is good and current for copper. For example, work on salmonid olfaction and copper conducted by McCarthy et al. (2007) is important and is cited. The inhibiting effects of copper on olfactory receptor neurons cited by McCarthy et al. (2007) at or above 2ug/L are lower than the Alaska hardness-based standards and the biotic ligand model (BLM) standard in Table 5-14 but above the biotic ligand model standard in Tables 5-15 and 5-16. I assume this is due to differences in binding of copper by dissolved organics, but am not sure. Whether one decides to use the 2ug/L benchmark or the even lower BLM benchmarks that are in some cases below background values in Table 5-19, I think the key question is whether proposed leachate processing can cost-effectively achieve benchmarks that hover around background concentrations. The answer is beyond my level of expertise.

I do not agree with the assessment's critical question whether or not effects are observed at these low levels (page 5-57, Exposure-Response Data from Analogous Sites, second sentence). If effects are observed at background concentrations, it seems unreasonable to ask for an even lower benchmark than background concentrations. The uncertainties assessment at the bottom of page 5-57 also seems unreasonable. The possibility that background concentrations are not protective in particular cases seems highly unlikely for one of the most productive salmon communities in the world.

Question 4. Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?

David A. Atkins, M.S.

For the no-failure mode of mine operation, the risks to salmonid fish due to habitat loss and modification in the vicinity of the project are well described. Mitigation efforts may offset or replace some of these losses, but these efforts are currently not described or even known. It would be helpful to put these risks in the project vicinity in context with the fishery as a whole. In other words, is this risk significant (based on specific criteria) when considering the fishery as a whole?

Project proponents state that the mine will only impact a very small fraction of the watershed (presumably under a no-failure scenario). Therefore, it is important to establish whether this impact is significant, both in terms of the absolute impact as well as the effect of ecosystem fragmentation.

In addition, representatives of the Pebble partnership have stated in various forums and documents that they will preserve and even improve the fishery. Is this feasible? Are there precedents for mitigation and reclamation of mine impacts in similar ecosystems that have improved the fishery?

Construction of the transportation corridor could alter the habitat, chemistry, and the migration path across the corridor for the over 30 streams that the corridor will cross or come near. There report states that the corridor could affect 270 km of streams below the corridor and 240 km of streams above, but there is no way to assess the magnitude. Therefore, the impacts of the corridor on fish populations are unknown, and this impact is not described in a way that can allow a reviewer to draw any conclusion.

Steve Buckley, M.S., CPG

Risks to fish due to habitat loss and modification and changes in hydrology and water quality is overly simplified given the broad parameters used to model these potential risks. More specific details on the water balance would help define potential risks to fish from dewatering and habitat loss. For example, there is no attempt to identify groundwater flow paths and the specific response of various landforms to seasonal changes in precipitation and runoff, yet 34 pages are dedicated to an attempt to quantify these impacts. More detailed information is needed to accurately quantify the changes in anticipated runoff and infiltration in the proposed area to determine potential impacts to hydrology and water quality.

Additional ecological information on the contributing watershed area for each fish bearing stream crossing would help identify the potential impacts to fish due to the construction and operation of a transportation corridor.

Courtney Carothers, Ph.D.

Six key direct and indirect mechanisms are identified to pose potential risk to salmonid fish species: eliminated or blocked streams (87.5 – 141.4 km), reduced stream flow, removal of wetlands (10.2-17.3 km), indirect effects of stream and wetlands removal (downstream effects likely diminishing fish production), diminished habitat quality downstream of road crossings, and blocked movement of salmonids at road crossings. These mechanisms are described clearly. The report appears to appropriately describe the scale and extent of risks under a no-failure mode of operation, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

The assessment describes the number of stream miles impacted under each mode of operation, including miles blocked and eliminated. Less specific were descriptions of impacts due to sedimentation and leachates. What's lacking is quantitative estimates of spawning and rearing habitat that would be lost relative to total habitat available. Having this information would help provide perspective of overall risk to individual watersheds and the Bristol Bay watershed as a whole. Surface water characteristics of site watersheds within the area of probable impact are detailed in Table 5-17, but not for other streams and lakes in the broader watershed. More information should be presented where available. It's not clear whether potentially affected streams and lakes might be nutrient limited (seems that they might be given their dependence on MDN). For example, include N or P concentrations and some discussion about primary and secondary productivity.

I found risks to salmonid fish, due to operation of the transportation corridor, well-described with respect to spatial distribution of fish and their habitats.

Gordon H. Reeves, Ph.D.

The potential risks to the freshwater habitat of anadromous salmonids are appropriately characterized and described for the no-failure mode of operation. The report considered the primary potential impacts of mine development and operation that could impact habitat and quantified the impacts where possible. The analyses seemed sound and logical, given the acknowledged limitations about the actual mine location and operation.

One possible factor that could influence the results was the use of the USGS 1:63,360 maps for developing the stream network. These maps generally underrepresent the amount of small streams, which can be ecologically important contributors to the overall productivity of the freshwater habitat of anadromous salmonids. This is acknowledged in the limitations (p. 5-46). Thus, the potential loss and modification of habitat that the report describes could be considered minimal at this time. It would be prudent to confirm the accuracy of the stream layer developed from the 1:63,360 maps in any future analysis.

The potential impact of the mine development and operation on the productive capacity of the various river systems could be developed more fully to gain better insights into potential impacts of the mine. The authors considered the amount of habitat that could potentially be impacted by mine development and operation by estimating the stream length that would be impacted and by considering the percent of spawners of the various species (from ADF&G surveys) observed in potentially impacted areas. However, the productive capacity of given stream reaches for a given fish species can vary widely. Any additional analysis could consider using Intrinsic Potential (IP) (Burnett et al. 2007. Ecological Applications 17:66–80), which considers local geomorphic features to estimate the potential of a given stream reach to provide high quality habitat for a given species. The concept, developed for use in the Pacific Northwest (PNW), has been applied successfully for Chinook salmon in the upper Copper River (A. Bidlack, EcoTrust, Cordova, AK., unpublished). The IP model for Chinook salmon from the PNW that was used in the Copper River was modified after discussion with local biologists. Similar modification may be needed for the PNW IP model for coho salmon to be used in Bristol Bay.

Another factor that I believe merits further consideration is the potential impact of altered thermal regimes of discharge water from treatment facilities (p. 5-28). Warmer water could have potential ecological impacts, particular during the time when eggs are in the gravel. Eggs could develop more quickly and fry could emerge earlier as a result of even minor changes in water temperatures (see: McCullough, D.A. 1999. A review and synthesis of effects of alternations to water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. US Environmental Protection Agency, Seattle, EPA 910-R-99-010. 279 p.; and McCullough, D.A., J.M. Bartholow, H.I. Jager, and 11 co-authors. 2009. Research in thermal biology: burning questions for coldwater stream fishes. Reviews in Fisheries Science 17: 90-113.). These changes could be significant, ecologically.

The report noted in several places that the potential impact on groundwater flows was not understood at this time but that disruptions of flow paths could have critical impacts on aquatic resources. One impact that was not mentioned is the loss of over-wintering habitat. K.M. Burnett (U.S.D.A. Forest Service, PNW Research Station, Corvallis, OR., draft report) found that the major overwintering areas for coho salmon in the Nome River, AK were at points of groundwater inputs. The groundwater influx created areas that were less likely to freeze during winter.

Charles Wesley Slaughter, Ph.D.

Yes, the risks to salmonids are well characterized with regard to the hypothetical mine operation itself. However, I suggest that the concept of "no failure", if taken as applying to the entire operation from inception through operation, is not realistic.

The Assessment makes a fair start toward considering the risks to salmonids from the potential transportation corridor. However, the many issues regarding stream and wetlands directly or indirectly affected by roads and pipelines are not fully explored. The extent (length, area) of streams and wetlands affected, as outlined in the text, should be considered a very optimistic lower estimate. The specific issues mentioned, such as bridge or road maintenance, culvert blockage or failure, erosion from cuts, fills, and the roadway itself, are all significant. I simply suggest that the potential consequences of imposition of the (hypothetical) transportation corridor, and future expansions consequent to ancillary infrastructure development and further additional resource extraction projects, would be broader, more severe and of more consequence (and thus should receive more emphasis) than the Assessment indicates. I suggest more fully incorporating Frissell and Shaftel's Appendix G into the body of the Assessment.

John D. Stednick, Ph.D.

The no-failure mode of operation is predicted to change the watershed contributing area and hence streamflow, and uses the boundary condition of a 20% change in streamflow as significant salmonid habitat loss. The assessment assumes a liner response between watershed area and streamflow contribution. Given the geologic and geomorphologic settings for the study area, are we comfortable that the watershed ridges delineate the watershed area? Groundwater movement may trump the physical watershed area. Similarly, is there potential for pollutant migration between watersheds via groundwater flows? Streamflow measurements from the gauged watersheds could be useful in answering this question. Similarly, the linkage of groundwater and hyporheic exchange could be expanded. Do these exchanges occur in all stream segments and gradients? Are water table or depth to water readings available? Is a groundwater monitoring program in place?

The multiple tables and hydrographs (pages 5-32 to 5-39) could be presented better. What streamflow changes are associated with what salmon species and life stage? A boundary condition for adults is different than for fry. Similarly, the proposed mine will use large quantities of water in ore processing and transport. How much is required and how will this affect water resources; both surface and groundwater? Climate variability is recognized as a game changer. What are the potential future scenarios for southwest Alaska for temperature and precipitation changes, and how will these scenarios affect water availability?

Pollutant assessment focused on copper and other metals can be presented to show the range of metal concentrations for chronic and acute toxicity, i.e., arsenic, molybdenum, silver, barium, and lead. Given the very clean waters (low hardness and organic carbon), the chronic toxicity of various metals should be evaluated. Water quality varies in time and space in the study area, and a better characterization of water quality could be developed. With streamflow records, metal loads could be calculated. What is the portioning of dissolved versus total metals? Are metals transported with sediments? Do organic carbon fluxes change in space or time?

No groundwater quality data were presented. Pollutant transport may include subsurface routes as well as surface routes. Please address.

Salmonid risk from travel corridor. The tentative road location has the potential to affect 270 km of stream between stream crossings and Lake Iliamna. The expected road erosion and sediment production has known effects on salmonid resources. The discussion of the travel corridor does not include the potential for road failures, landslides, blocked culverts, and ditch failure. The discussion does not talk about traffic volume or the potential of hazardous material transport on the travel corridor.

There is no discussion of water processing after delivery of the slurry to the sea port and return of waters back to the mine site.

Roy A. Stein, Ph.D.

No-Failure Mode of Operation. My comments re the no-failure mode of operations and their impact on salmon can be found under Question 3.

Road Use I: Page 5-60. Beyond calcium chloride, how can we be confident that the typical chemicals that derive from highway use will not occur on this mine road (as noted on page 5-60)? Is it because the low volume of traffic? If so, would not we expect accumulation through time…over the 78 years of the mine operation (see Appendix G for some detailed analysis: should some of this material be added to the Main Report?)?

Road Use II: Page 5-62 to 5-63 (plus Appendix G). Will there be frost heave of the road bed such that specific structures will have to be installed to prevent this movement of the road bed? These roads will be treated with chemicals, such as calcium chloride, to keep the dust down and contribute to an ice-free condition but no data are available for the impacts of these chemicals on nearby streams. How then do we deal with this issue (page 5-62 and 5-63)? The suggestion is that one needs to have roads built at least 8 meters from streams, but this cannot be the case in this situation, simply because of the large number of streams, rivers, and wetlands along the road corridor?

Road Use III: page 5-71 (plus Appendix G). The road will intersect multiple streams and rivers along the northern end of Iliamna Lake, where as many as one third of the sockeye salmon in this lake spawn. And this is where the causeway across Iliamna Lake will be built as well. From my perspective, it seems that impacts on spawning sockeye will be large in this area (without saying anything about causeway: will there be culverts or bridges to allow water and fish to communicate with the rest of the lake)? I would argue this is important, given salmon are attracted to certain odors and water-flows and these odors and water-flows are coming from inlets streams into Iliamna Lake. Preventing any sort of blockage of water flow or salmon migration would be the goal. Are there other issues that should be considered when building this causeway?

William A. Stubblefield, Ph.D.

The document appears to adequately address potential questions associated with habitat loss due to hydrologic changes, especially considering the hypothetical nature of the mine and the lack of specific detailed information regarding an actual proposed facility and all of the associated operational details of the facility. The assessment of potential impacts and ecosystem protection parameters is predominately based upon the publication of Richter et al. (2011). Additional support and evaluation of these recommendations for fisheries populations in the Bristol Bay area should be closely evaluated.

Dirk van Zyl, Ph.D., P.E.

Chapter 5 of the EPA Assessment is entitled: "Risk Assessment: No Failure". Chapter 5 presents an evaluation of habitat loss and modification resulting from the hypothetical mine. A summary of the "risks" associate with the "no failure" case is provided in Chapter 8. There is specific focus on evaluating the magnitudes of the losses and modifications to the environment.

A risk assessment addresses three questions (Kaplan and Garrick, 1981):

- What can happen? (i.e., What can go wrong?)
- How likely is it that that will happen?
- If it does happen, what are the consequences?

There are a large number of risk assessment methods and it is common to express the magnitude of risk as a combination of likelihood of occurrence and consequences (IEC, 2009). This is the typical outcome for engineering assessments of systems. For example, in the case of a Failure Mode and Effects Analysis (FMEA), it would be typical to develop a risk matrix to combine likelihood of occurrence and consequences to express the level or magnitude of risk in qualitative terms (Robertson and Shaw, 2012).

The EPA Assessment describes the two components of risk but does not provide any information on the magnitude of the risk. For example for the no-failure condition it describes the length of streams, areas of wetlands, etc. that will be impacted by developing the mine, i.e. the consequences. One may argue that the likelihood of occurrence of these consequences is unity (or certainty) if the mine is developed, as this is not specifically addressed by the report. One would next expect an expression of the magnitude of this risk based on some comparison of the consequences to a set of outcomes that could result in acceptable or unacceptable risks. The EPA suggests this as an approach in its 1998 Guidelines for Ecological Risk Assessment (EPA 1998): "In some cases, professional judgment or other qualitative evaluation techniques may be used to rank risks using categories, such as low, medium, and high, or yes and no". Quantitative approaches such as fuzzy logic has also been used to develop expressions of magnitude of risk as described by EPA (1998): For example, Harris et al. (1994) evaluated risk reduction opportunities in Green Bay (Lake Michigan), Wisconsin, employing an expert panel to compare the relative risk of several stressors against their potential effects. Mathematical analysis based on fuzzy set theory was used to rank the risk from each stressor from a number of perspectives, including degree of immediate risk, duration of impacts, and prevention and remediation management. The results served to rank potential environmental risks from stressors based on best professional judgment".

For example, it is unclear to the reader how significant a loss of 87.5 km of streams in the Nushagak River and Kvichak River watersheds is to the overall ecosystem. Are there any criteria that can be used to develop such an expression? Can a multi-stakeholder workshop (as is often done) be used to develop such criteria and expressions of risk magnitude? Without having such expressions of risk magnitude it is impossible for those without specific expertise in salmonids to evaluate whether this is a significant risk. Price, et al (2010) states that: "Between 1999 and 2008, 3,500 fish passage barrier culverts were replaced with fish-passable structures, reportedly opening nearly 5,955 km of fish habitat in Washington streams (Governor's Salmon Recovery Office 2008)". Comparing the loss of 85 km to this gain of 5,955 km seems to imply that 85 km loss represents a relatively small risk, which may not be the case at all. However, the EPA Assessment does not provide any insight in the magnitude of risk except to provide a value for the consequences.

Similar comments can be made with respect to the relative risks associated with the other losses of ecological functions for other failure modes.

It is recognized that it is important to maintain separation between the risk assessment and risk management functions. As expressed by the National Research Council Panel in their report on Science and Decisions (NRC, 2009): "The committee is mindful of concerns about political interference in the process, and the framework maintains the conceptual distinction between risk assessment and risk management articulated in the Red Book[2]. It is imperative that risk assessments used to evaluate risk-management options not be inappropriately influenced by the preferences of risk managers".

Providing an expression of risk magnitude should not interfere at all in the separation of risk assessment and risk management but should provide the risk manager with one extra level of analysis and insight from the expert assessor of the problem at hand. Multi-stakeholder interaction will only serve to enhance the value of the risk ranking.

On p 4-33 it is stated that after closure: "No PAG waste rock would remain on the surface". It is also stated in Chapter 4 that PAG and NAG waste will be segregated. On p 5-48 it is stated that: "However, the primary concern during routine operation would be waste rock leachate. That leachate would become more voluminous as the waste rock piles and uses of waste rock for construction increased during operation. After mine closure, it would be a major source of routinely generated wastewater along with water pumped from the TSF and pit. Leachate composition from tests of the three waste rock types (Tertiary, East Pre-Tertiary, West Pre-Tertiary) is presented in Tables 5-14 through 5-16". There is no specific indication which of these waste rock types could be described as PAG or NAG and Chapter 5 seems to assume that these 3 samples are representative of the total amount of waste rock, about 4 billion tonnes for one mine scenario. If all the PAG material will be removed from the surface as stated in the scenario in Chapter 4 and the NAG will not generate acid drainage then it is difficult to understand why the waste rock piles and waste rock used for construction (supposedly all NAG at this stage) would be the major source of "routinely generated wastewater." It is further unclear why there would be water pumped from the tailings and the pit if the TSF were closed as discussed above and if it will take the mine pit 100 to 300 years to fill. Some clarification is in order.

A further reference to the fate of waste rock after closure is found on p. 5-77 of the EPA Assessment: "Under the mine scenario, the mine pit, waste rock piles, and TSF would remain on the landscape in perpetuity and thus represents permanent habitat loss." It should be noted that the PAG will not remain on the surface, whatever volume and area of land surface that presents.

The descriptions of exposure and exposure-response resulting from the transportation corridor in Section 5-4 of the EPA Assessment focus on potential impacts and make use of references that are clearly not representative of the expected road construction. A number date from 1975 and 1976 (p. 5-59) that is not necessarily representative of road design and construction practices in 2012. On p 5-62 the following statement and reference is given: "Sediment loading from roads can severely affect streams below the right-of-way (Furniss et al. 1991) and references therein)". This reference is specifically focused on forest and rangeland roads, clearly not representative of

[2] The so-called "Red Book" refers to: National Research Council (NRC). 1983. Risk Assessment in the Federal Government: Managing the Process, Washington, DC: National Academy Press.

a major transportation road between a mine and the port facilities from where its products are shipped. This publication contains many recommendations specifically for forest and rangeland roads and some of them are indicative that it is not applicable to the transportation corridor for a major mine access road: "Design cut slopes to be as steep as practical. Some sloughing and bank failure is usually an acceptable trade-off for the reduced initial excavation required" p. 306; and "stream crossings can be considered dams that are designed to fail. The risk of failure is substantial for most crossings, so *how* they fail is of critical importance" p. 310. The reference also refers to the application of oil as a dust abatement additive on p. 312, this is hardly acceptable practice. In my review I did not find that any of the references used in the EPA Assessment refers specifically to mine roads such as that considered for the transportation corridor at the Pebble Mine scenario.

It is further interesting that it is stated on p. 5-60 that there will be 20 bridges and 14 culverts along the road without referring to this as an assumption and no reference is cited for this information. Will there be a change in impact if the decision is made to build 30 bridges and 4 culverts or 34 bridges and no culverts?

The discussion on the potential impacts of the transportation corridor on salmonids serves the purpose of highlighting some aspects that engineers and fish biologists can take into account when designing and maintaining the final transportation corridor for the Pebble Mine and other mines in the Bristol Bay area. However, this assessment does not appropriately describe the scale and extent of the risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation.

Phyllis K. Weber Scannell, Ph.D.

The no-failure model makes a number of assumptions about how the mine will be developed – some may be accurate, some may be considerably different. It is important to take under consideration that Pebble is currently a prospect, not a mine. Should this project proceed to mine development, it will be incumbent on the mineral development company to develop a rigorous mine plan that includes detailed information on all aspects of a future project. This mine plan will be reviewed by state and federal staff with experience in large project development. In other projects, state and federal experts have worked with resource developers to use part of the project to create or enhance wetland and aquatic habitats for fish, bird and wildlife species. Examples of habitat enhancement include development of critical fish overwintering habitats on the North Slope in conjunction with gravel mining, development of wetland complexes and establishment of a reproducing Arctic grayling populations in the freshwater reservoir at the Fort Knox gold mine, development of habitats to sustain a spawning Arctic grayling population at the Bons Creek fresh water reservoir at the Red Dog Mine and development of the Chena Lakes Recreational Area in conjunction with the flood control project. These projects demonstrate the success of agency involvement in early stages of a resource development project that can lead to protection and possible enhancement of habitats for fish, bird and wildlife species.

The no failure model discusses the amount of riverine habitat that will be lost to mineral development by the mine pit, tailing storage facility and waste rock dumps. Anadromous fish habitat is protected under Alaska Statute 16.05.840-870. The statute requires review of a project potentially affecting fish habitat and, where necessary, avoidance, mitigation or compensation. A project must provide free passage of fish; the project cannot be placed in such a way that fish are prohibited from moving into the upstream reaches.

There are many aspects of the development of a large mine project that need thorough review to ensure that habitats are protected. These include, but are not limited to: classification and storage of waste rock, lower grade ore, overburden and high grade ore; development and maintenance of tailings storage facilities; development and concurrent reclamation of disturbed areas, including stripped areas and mine pits; collection and treatment of point and non-point source water; quantity and timing of discharges of treated water; monitoring of ground water, seepage water and surface water; and biomonitoring. The transportation corridor will require review and permitting of every stream crossing of fish-bearing waters. In addition, plans should be developed for truck wheel-washing to minimize transport of contaminated materials.

Paul Whitney, Ph.D.

Material resource areas mentioned on page 4-34 for the road and pipelines should be discussed in more detail. Will aggregate be required? If so, where are the aggregate resources in relation to floodplains? I spent a summer surveying material resource areas for a proposed arctic and subarctic pipeline and access road. Suitable material resources areas are sizeable and are often important (e.g., aggregate) for wildlife such as bears that hibernate or survive the winter in dens and fishery resources. Sometimes dens can only be excavated in non-permafrost (i.e., aggregate) soils. It appears that the project area is in a zone of discontinuous permafrost but permafrost could be more continuous in the higher elevations along the road through the Kenai Mountains. An accurate assessment should determine the permafrost location(s) as well as the area and importance of material resources for fish and wildlife. In addition, Reclamation Plans for the material resource areas should be briefly discussed to ensure that areas mined for aggregate will not avulse and capture streams.

Dust control for the 86-mile proposed haul road will likely require a lot of water. Where will this water come from? Withdrawal from streams crossed by the haul road could have impingement and flow reduction consequences. Adequate screening could solve the impingement issue. Some back-of-the-envelope calculations could determine if water withdrawals for dust control could alter the projected hydrographs when salmonids are present in the streams.

Question 5. Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?

David A. Atkins, M.S.

The Assessment presents summaries of failures at existing mines that encompass the full range of possibilities. Anecdotal information regarding mine failures is numerous, but often not well document, so it is difficult to get information on the specifics.

Bristol Bay and the Pebble Project are unique in the environment and significance of the resource as well as the scale of the deposit. To my knowledge, there is not a similar project in this regard in existence. Therefore, I do not know of good analogues other than those mentioned.

Regarding the estimates of probability of failure, the report stresses the wide range of uncertainty, depending on design and environment. Without a more detailed understanding of the mine plan and associated engineering, as well as additional detailed analysis, it is difficult to determine if the failure probability estimates presented are reasonable.

Steve Buckley, M.S., CPG

The engineering failures reasonably represent potential system failures outlined in the mine scenario based on historic porphyry copper deposits of this type. It is less clear if the failures reasonably represent a mine scenario based on state of the art engineering and mitigation practices. Appendix I provides some information related to potential system failures and possible mitigation measures designed to minimize these risks but these are not treated in any detail in the assessment. It would be difficult to pull together the most modern engineering and mitigation practices from around the world but it could help bound the risks associated with modern mine development.

The Red Dog mine in northwest Alaska might be relevant for estimating potential mining activities in the watershed. Although the characteristics of the deposit differ significantly, at roughly 150 million tons, it is half the size of a reasonable minimum mine scenario and would be helpful to characterize some minimum mine development scenario.

Courtney Carothers, Ph.D.

The potential failures outlined in this assessment include: tailings dam failures, pipeline failures, water collection and treatment failures, and road and culvert failures. These failures appear to represent the key potential failures for this mining scenario, their risks appear to be estimated reasonably, and statistics from existing mines appear to be used appropriately, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

My experience in system failure of mines of the size and type outlined in the scenario is limited. However, what does seem to be missing is the long-term effects of leachates to receiving water bodies in any type of risk scenario, including both non-failure and failure modes. That is, assuming no catastrophic failure, how might tailings constituents interact with aquatic habitats seasonally, such as during periods of snowmelt and severe rainfall events?

Gordon H. Reeves, Ph.D.

This is an area outside my expertise and I am unable to evaluate and assess the adequacy of what was presented.

Charles Wesley Slaughter, Ph.D.

Potential failures seem reasonable, based on history of other mining operations. However, the consequences of hydrologic extremes during winter (frozen soil) conditions are not adequately addressed. The possibility of the mining operation and the transportation network encountering discontinuous permafrost is not mentioned, although at least some soils maps indicate permafrost presence.

The probability approach outlined for potential TSF dam failure is unpersuasive. It is difficult to relate to a number like "0.00050 failures per dam year", or to the implication (p. 4-47) that one can expect a tailings dam failure only once in 10,000 to one million "dam years". This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult to interpret, given the lack of historical seismic record for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212. (The suggested 200-year return period should also be viewed in light of the 79-year suggested operating life of the hypothetical Pebble operation, probable longer-time operations at other mineral extraction sites, which would be developed following implementation of Pebble and building from the infrastructure associated with Pebble, and also the projected very long persistence of the TSFs following cessation of active mining).

Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety."

John D. Stednick, Ph.D.

The assessment reasonably addresses potential system failures.

Tailings storage facility (TSF). The liquefaction phenomenon, internal and external erosion, seepage, and overtopping are some of the main failure modes of tailings storage facilities. A large quantity of stored water is the primary factor contributing to most tailings storage failures. The risk of physical instability for a conventional tailings facility can be reduced by having good drainage and little (if any) ponded water. Some suggest that the tailing pond freeboard should be able to accommodate the 100-year, 72-hour storm/streamflow event. Discuss the probability of failure of a TSF, other than overtopping by a precipitation/streamflow event.

Chemical transport spill. Mine development and ore processing will require significant loads of petroleum and chemical products. Although the exact processing formulations were not given, most copper porphyry mines use similar formulation in ore flotation and processing. How will chemicals be stored, transported, and recycled. What are the opportunities for accidents to occur?

Roy A. Stein, Ph.D.

Failures Appropriate for Mines of this Size and Type. Given my background, I can't answer with any authority, though the comparisons seemed appropriate, though clearly no extant mines are as large as the one proposed herein.

Failures Not Described? I speak to failures associated with routine operations later in this review.

Probabilities and Risks of Failures. These seemed reasonably well documented, though again this falls outside of my expertise.

Existing Mines as Comparisons. Given my background, I can't answer with any authority, though the comparisons seemed appropriate, though clearly no extant mines are as large as the one proposed herein.

Proportional Losses of Salmon. Is it possible to estimate the proportion of the salmon runs compromised in the face of major failures in tailing storage facilities or other failures? In other words, I would recommend adding a chapter that uses best estimates of salmon produced within the Bristol Bay watershed and then assess the maximum impact of, let's say, a Tailing Storage Facility failure---with this failure, might we lose 10%, 40%, or 75% of our salmon productivity? In addition to this estimate, one might estimate the number of stocks or unique genetic units lost with a major failure? I know these numbers are difficult to get but if one begins with escapement from these systems as well as insights from harvest, we may be able to bound these impacts. Only in this fashion can we put these data into context.

Correlations between Ocean and Terrestrial Conditions. From the literature (see Irwin and Fukuwaka. 2011. ICES *J. Mar. Sci*. 68: 1122 as just one example), we know what climatic conditions lead to poor rearing conditions in the ocean, thus compromising growth and ultimately survival of salmon. Given these ocean conditions, might we have correlative effects in the terrestrial environment, thus leading to a cumulative effect of ocean and terrestrial impacts? For example, if particular oceanic conditions underlie poor survival, might this correlate with an increased probability of flooding, leading to a higher probability of a Tailings Storage Facility failure, leading to a cumulative synergistic effect that could be multiplicative in its negative impact on salmon populations? Was there any attempt to correlate these impacts? Just how realistic is it to reflect on these sorts of multiplicative effects? Might these effects have a catastrophic effect on salmon populations?

William A. Stubblefield, Ph.D.

The scope of failures described in the assessment seems to be sufficiently comprehensive and that all likely failure-types are considered. The probabilities and risks for failure seem to be adequately estimated, given the state-of-the-science; however, these estimates are likely to be very sensitive to site-specific concerns and operational considerations. Once site-specific information is available, it is likely that much better estimates of failure potential at a site can be developed.

Dirk van Zyl, Ph.D., P.E.

Failure modes outlined in the EPA Assessment do not reasonably represent the potential failures that could occur at a mine of the type and size outlined in the mine scenario.

The failure modes considered in the mine scenario include four major items: tailings management facility; pipelines; water collection and treatment; and, road and culvert. It is reasonable to evaluate these failure modes for a mine of this type and size, either qualitatively as is typically done in FMEA, or quantitatively. There are no other significant types of failures that are not described. However, I do not agree with some of the analysis details for the failure modes, as discussed below. The risks of failures are not estimated appropriately as they are not estimated at all. The likelihoods of failure and their consequences are estimated in Chapter 6. However, there is not a complete risk analysis. Refer to discussion in Question 4 above.

TSF failure likelihood. The failure statistics given on p. 4-45 are based on tailings failure statistics over the last 50 years or so. Was there also a review of the operational histories, and therefore failures, of tailings impoundments designed and constructed in the last 10 to 15 years? It is recognized that one of the failures identified in Box 4-4 (Aurul S.A. Mine, Baie Mare, Romania) falls in this category. However, many of the failures included in the analyses are associated with older tailings facilities, especially those associated with large releases of tailings solids. A significant improvement in tailings management is the implementation of an Independent Tailings Dam Review Board (ITRB) for large mining projects (Morgenstern, 2010). An example of the activities of an ITRB is given in Minera Panamá (2012). Morgenstern (2010) provides a listing of tailings failures from 2001 and 2010 and comments that "in no case, to the knowledge of the Writer, was there systematic third party review" of the failed facilities as would be the practice when an ITRB is active. I expect that a tailings review board will also be used for the Pebble Mine and the behavior of a tailings management facility designed and operated under these conditions will be more representative of the potential failure likelihoods expected for such a facility. It is expected that this likelihood will be much lower than those used in the evaluations of the scenario in the EPA Assessment.

TSF failure consequences. It is difficult to estimate the volume of tailings that will be released when a tailings impoundment fails. The release of 20 percent of tailings from a slurry deposited TSF may be realistic when it contains a large pool and is subjected to a large flood, but it is unrealistically high for a TSF containing a small or no pool (such as in the case of a filtered dry stack). I would consider the assumption that releasing 20% of the tailings material for the Pebble mine scenario is on the high side, even during operations. When the mine is closed and the tailings reclaimed I would consider the 20% release assumption as unrealistic, especially if the closure implementation included a diversion system designed for the PMF. It is further unrealistic to assume that the released tailings will remain in the downstream channels and flood plains following the failure. In the case of the Aznalcóllar Tailings Dam failure in Spain all the released tailings downstream of the mine were removed. While such a removal action will impact parts of the watershed it will help to recover the area faster than leaving the tailings in place and will also reduce the longer-term impacts on downstream water quality. I therefore disagree with the assumption on p. 6-2 that "the assessment assumes that significant amounts of tailings would remain in the receiving watershed for some time and remediation may not occur at all." Box 6-1 provides "background on relevant analogous tailings spill sites" and three historic sites are used as analogs. These are not realistic analogs as they all relate to historic mining under completely different scenarios. While the material historically released in these streams were from base metal mines the circumstances of their release, especially in the case of the Clark Fork and the Coeur D'Alene Rivers, were very different. Long-term uncontrolled releases occurred in these river systems due to regulatory circumstances or historically acceptable practices that differ significantly from those in the 21st Century.

Pipelines failure likelihood. The EPA Assessment focuses on the failure of the concentrate pipeline because "We do not assess failures of the natural gas or diesel pipelines here because such pipelines are common, their risks are well known and they are not particularly associated with mining". I find this statement puzzling because all pipeline failures should be of concern. It is further puzzling because the likelihood of pipeline failures for the concentrate pipeline is derived from the failure statistics for pipelines in the oil and gas industry (p. 4-60). Failure of the Baja de la Alumbrera concentrate pipeline in Argentina is suggested as an analog, indicating that such failures can occur, however I disagree that "it suggests that concentrate pipeline failures are common at a modern copper mine.." This last statement is not supported by any further analysis of concentrate pipeline failures at other modern copper mines. It is recommended that such analyses be performed or that the text be edited to indicate this shortcoming.

Pipelines failure consequences. Failure consequences are focused on the release of concentrate into water. As indicated in Appendix H of the report, the analog concentrate from the Aitik mine, is dominated by chalcopyrite a sulfide mineral (which contains the copper). If the concentrate is submerged under water in relatively slow flowing streams then very little long-term release of the copper will occur as the water does not contain sufficient oxygen to allow for sulfide oxidation. It is only when the concentrate is transported to locations above the water level that oxidation and release of metals will occur. I am not a geochemist and can therefore not comment on the evaluations used by the EPA in their exposure analysis and it is recommended that this be reviewed by a geochemist. I find it difficult to understand the magnitudes of the concentrations in Table 6-7 as they do not seem to be contained in Tables 8 or 9 of Appendix H.

Water collection and treatment failure likelihood. An estimate is presented for the amount of seepage that may flow from the TSF. Similar estimates are not presented for the waste rock piles. The effects of the effective exclusion of oxygen from the saturated or partially saturated tailings should be considered in developing an estimate of the water quality of the resulting seepage. It may be an important factor in reducing the oxidation of sulfide minerals remaining in the interior of the TSF. This same effect could also mitigate the release of poor water quality in the long-term following closure. The precipitation on the site may be sufficient to effectively retain a suction saturated profile in parts of the TSF.

Water collection and treatment failure consequences. Water collection and treatment is being done at a number of mines in North America. Past experience at the Red Dog mine is quoted, however there are many other examples that could have been examined. An important example is that of the Equity Silver Mine in British Columbia (Aziz and Meints, 2012): "Acid Rock Drainage (ARD) was discovered at the Equity Silver Mine in the interior of British Columbia in 1981. The latest water treatment plant was installed in 2003, 9 years after the mine closed in 1994, and is the fourth successive treatment plant for the site that has treated ARD for a period of over 30 years. Discharge water quality was maintained since 1991 except during two high flows associated with freshet conditions in 1997 and 2002. ARD collection and treatment system upgrades were installed after 2002 and these have performed well through three large freshet conditions in 2007, 2011 and 2012. The timeframe for treatment is perpetuity and financial assurance is in place for a total amount of $56.291 through a long-term security bond (letter of credit) with the BC Provincial Regulatory Authority. The security bond is reviewed by stakeholders every 5 year". Collection and treatment at Equity Silver indicates that companies are committing to long-term water treatment of ARD and that regulatory frameworks are in place to protect water quality in downstream streams and rivers. Further work will be required to investigate experiences at other sites.

Road and culvert failure likelihood. The likelihood of road and culvert failures is discussed in Section 4.4.4 (p. 4-62). This section relies on the paper by Furniss, et al (1991) for a number of aspects. As was pointed out above, this paper is focused on forest and rangeland roads and not applicable to the access road for the Pebble Mine. It is recommended that further evaluations be done of similar roads at mines constructed between mines and port facilities to update this section.

Road and culvert failure consequences. The failure consequences discussed in section 6.4 seem to be based on almost total regulatory failure during and after operations. The information also serves to highlight the aspects that should be considered when designing, operating and maintaining the access road during operations and subsequently during closure.

The responses above identify the information from other sources that can be used to obtain further information about failure likelihoods and consequences.

Phyllis K. Weber Scannell, Ph.D.

This section focuses on catastrophic failures; however, there are a number of non-catastrophic failures that can occur at a mine site. Non-catastrophic failures include leakage of contaminated water to ground or surface waters from PAG waste rock, the tailing storage facility, and exposed ore surfaces. These potential sources of contamination can be minimized by site locations, monitoring and remediation. Non-catastrophic failure can occur if untreated water is discharged from the tailing pond because of un-anticipated water level increases. Mines have discharged untreated water to prevent dam over-topping; this "failure" can be mostly prevented with good site planning and monitoring. An additional "failure" has been experienced at a mine in Alaska when the water elevation of the tailing pond was sufficiently high to cause groundwater flow across a natural divide into an opposite drainage. This "failure" can be minimized by site planning, monitoring and remediation plans should ground water migration occur.

Paul Whitney, Ph.D.

The failure analysis indicates that a sediment transport study was beyond the scope of the assessment. Not only is such a study important for fish resources, it is important for all ecological resources, especially plant community succession along the stream and delta into Bristol Bay. This might seem extreme, but I'd like to know why the Koktuli, Mulchatna and Nushagak Rivers would stabilize into a new channel and not continue to work their way across the floodplain and eventually transport materials hundreds of miles down river. The Mt. St. Helens eruption (given as an analogy in the assessment on page 6-3) certainly moved sediment into the Columbia River Channel, the Columbia River Estuary and Pacific Ocean (e.g., Table 7-1 where 9 of 11 deposit types have gold), over a hundred miles away. Copper concentrations in the Columbia River estuary as a result of the eruption ranged from 1 to 43 ug/L (Lee 1996). The upper limit of the range is approximately 20 times greater than the no effect benchmark listed in the assessment. The down stream consequences of changes in sediment transport and water/sediment chemistry for fish and wildlife are sometimes very large, not anticipated (see Peace Athabasca Delta response below) and costly to remediate. Solutions for the Peace Athabasca Delta involving check dam construction may not be directly applicable to a tailings dam failure analysis in the assessment but may have some value short of dredging. I'm not sure how it would work, but a mitigation effort (page 4-32, para 3, last sentence) using bulk tailings would apparently be placed down gradient to catch tailings in the event of a failure. Is this a safety check dam? It is possible that the assessment could be improved if this and other redundant efforts to minimize risk could be discussed in more detail and considered in the failure analysis.

I agree with the assessment statement (page 6-11, 6 lines down) that impacts of a tailings dam failure to fish would extend down the mainstem Koktuli River and possibly further. If the Mount St. Helens analogy is a good one, the impacts could reach Bristol Bay. I also agree with the assessment statement that the time to reach dilution approaching background would be very long as the sediments in tributary rivers to Bristol Bay will be continually reworked (page 6-25) and resuspended.

As a terrestrial ecologist, I have always been impressed by the impact of Bennett Dam on sediment transport in the Peace Athabasca Delta ecosystem over 600 miles away (Cordes 1975). The assessment does mention the potential impact of toxics on the likelihood of plant community succession on deposited tailings (page 6-10) but this causal pathway was not assessed. Given the increases in metal concentrations in the Columbia River Estuary cited by Lee (1996) for the Mount St. Helens eruption, an assessment of down stream sedimentation and changes in sediment chemistry should be addressed. The likelihood that far reaching impacts of a failure could influence plant succession and wildlife habitat quality is probably not anticipated but given the Mount St. Helens analogy and the lessons learned from Bennett Dam, the likelihood of such impacts deserve more attention.

Once again, as a terrestrial ecologist with ecological risk assessment experience, I know that sediment chemistry and determining toxic benchmarks for sediments is very complex and subject to varied opinions. I admire the MacDonald et al. (2000) effort to reach consensus on sediment benchmarks, but I have three concerns. First, the consensus values listed in MacDonald et al. (2000) are geometric means of values from several sources. The mean consensus values likely do not equate to No Observed Effect Concentrations, which would probably be lower than the mean values. Second, the lack of observed effects was sometimes for a "majority" of sediment dwelling organisms, but not all (MacDonald et al. 2000, Table 1). Third, some of the sources used for the mean values included interstitial water but apparently not all (Table 1). I will always remember Dr. John Stein (currently the acting director of NOAA's Northwest Fisheries Science Center in Seattle) standing up at a workshop for the Columbia River Channel Deepening Project. He had a small bottle of sediment and water in his hand and while shaking it he said something to the effect: It's the pore water we are interested in. Considering that a proposed mine, at some point, will be reviewed by NOAA, it seems appropriate to consult with NOAA regarding benchmarks for all the species of sediment/pore water-dwelling organisms likely to occur in the potentially effected watersheds addressed in the assessment.

Question 6. Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

Water treatment failures occur at virtually every site that treats water, and mine sites are no exception. The risk of failure of water treatment described in the assessment is useful as background, but as the report states, the risk is highly uncertain. During mine operation, a lapse in treatment would likely be identified and addressed quickly. This type of treatment failure is ephemeral and would likely have a short-term impact on the fishery, depending on the time of year of occurrence. It is likely that any impacts to the fishery could recover in subsequent years after the problem is fixed. The site will require water treatment long after closure, possibly in perpetuity. This period is more problematic, as a water treatment failure could not be noticed for some time or the resources may not be available to correct it quickly, depending on how long after closure the failure occurs and the stewardship of the treatment system.

Steve Buckley, M.S., CPG

Less than a page (p. 4-39) is devoted to the failure of water and leachate collection and treatment. This seems inadequate, given it would be one of the main systems that could impact fish at the potential mine site. In contrast, 20 pages are devoted to tailings dam failure (p. 4-39 to 4-60).

Courtney Carothers, Ph.D.

The report concludes that wastewater and leachate treatment and collection failures could expose local streams to mildly to highly toxic water harmful to invertebrates and fish species. Depending on the type of failures, these exposures could last from a period of hours to years. The report notes that in the case of Red Dog Mine, Alaska, the water treatment system was inadequately designed, but does not discuss why such a design was approved and allowed to be implemented, nor does it discuss the likelihood of replicating such a design flaw in future mining scenarios.

Dennis D. Dauble, Ph.D.

More information on local hydrology, including seasonal runoff patterns and groundwater movement would be useful. I found no description of existing water quality characteristics of potential receiving waters, except what is included in Table 5-17 of the main document. Are these values (such as hardness, which moderates metal toxicity) consistent throughout the watersheds, including lakes? Other questions include: What volumes of leachates might be collected and treated versus volumes not captured and subsequently released downstream. Is copper the only constituent of concern to aquatic animals?

The assessment should also consider and discuss relative risk to aquatic ecosystems from downstream transport of sediment-bound metals to Iliamna Lake, if deemed probable.

Gordon H. Reeves, Ph.D.

The primary impacts are from the toxic effects of the water and leachate on fish and aquatic invertebrates. This is outside my field of expertise so I am unable to assess the appropriateness the risk characterizations or to provide insights about additional literature.

The report focused primarily on the lethal effects of the contamination from leachate and water treatment and collection failures. However, could there be ecological consequences to fish and invertebrates that are not directly lethal but that could have ecological consequences over the long term? I suggest that this needs to be considered more fully in this assessment.

Charles Wesley Slaughter, Ph.D.

No. Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.

Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures", "excess captured water would be treated…and discharged to nearby streams…." – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release, to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendix A, Appendix B).

John D. Stednick, Ph.D.

The TSF is designed to hold the tailings under water to minimize the oxidation of pyritic materials and limit ARD or AMD production. The TSF will be underlain by hypalon (?) to capture leakage waters. There is the possibility of failure to collect waters from the TSF—either surface runoff or leakage with or without storm (precipitation) events. There is the possibility of failure of the treatment plant to treat the wastewater. Such treatment systems in Colorado usually have a bypass pond to temporarily hold waters for later pump back and treatment due to power failure, plant going off-line, storm event, or plant maintenance.

The waters in the study area have very low buffering capacity and metal toxicity would occur at low concentrations, and dilution of metals would require time and space. The maximum index counts on page 6-39 are confusing and not well related to the risk characterization. Copper was used as an example metal, but other metals are also toxic and further characterization of the waste rock can be presented. Further analysis of a water and leachate collection failure can be made over time on the effects of dilution flows over the various months with low flows or when adult salmon are present in the stream as opposed to juveniles. Or when juveniles are emerging. The toxicity quantification is difficult and appears more of an academic exercise here, rather than site specific.

Most, if not all of these failures are the result of human error. What safeguards will be in place? What are the best mining practices to minimize human error?

Roy A. Stein, Ph.D.

Groundwater Connectivity and TSF Construction. Extensive connectivity between surface water and ground water means that any failure will allow contaminated waters to flow quickly to areas of importance for salmon. And, indeed how does one build a tailings pond (coarse textured glacial drift in the Pebble Mine area) with this much permeability?

Tailings Storage Facilities: A water-impermeable barrier will be installed only on the interior dam face and nowhere else. To prevent communication between these facilities and the groundwater, is it feasible to map groundwater inputs before the facility is filled, place barriers over these areas, and thereby reduce influx of groundwater into the facility and perhaps prevent movement of toxic water into the ground water? I make this point with some hesitation, given the point made on page 5-29:

> "Projecting specific mining-associated changes to groundwater and surface water interactions in the mine area is not feasible at this time."

Failure of Leachate and Water Collections. See my comments under Question12 below.

William A. Stubblefield, Ph.D.

The risk assessment attempts to consider the effects of metal discharges for water and leachate from the mine site. This assessment is based on metals concentrations measured in potentially "similar" mine waters from other sites; concentrations of metals are likely to differ based on source material and operational differences. The effects concentrations used in the evaluation are based on US EPA ambient water quality criteria (AWQC) for metals, and this approach is appropriate for "screening level" evaluations. It should be noted that exceedence of an AWQC does not portend the occurrence of adverse effects. Ambient water quality criteria are derived in such a way that it is intended that these are considered "safe concentrations." In other words, if environmental concentrations remain below the AWQC, it is assumed that unacceptable adverse effects will not occur; exceedance of an AWQC suggests that adverse effects may occur to some species, but that this must be evaluated more closely. Salmonid species are not the most sensitive organisms in the copper AWQC species sensitivity distribution (SSD), therefore direct effects on salmon are even less likely at concentrations in the range of the AWQC.

It is interesting to note that the risk assessment document states that copper is one of the "best-supported criteria. However, it is always possible that it would not be protective in particular cases due to unstudied conditions or responses." Further, the document goes on to suggest that organisms such as mayflies, etc., are important to the aquatic ecosystem but are not considered in the copper AWQC and therefore may not be sufficiently protective. It also suggests that because an acute-chronic ratio approach is employed to correct the final acute value to obtain a final chronic value, there may be increased uncertainty associated with the protectiveness of the chronic criterion. This appears to be an area where EPA might benefit by conducting research (either alone or in concert with industry) to reduce uncertainty in the criteria to an acceptable level. In addition, additional chronic toxicity data may be available from research conducted in response to the European REACH regulations and consideration of this research may reduce the level of uncertainty in the criteria. Bioavailability correction via the BLM approach is only considered for copper in the risk assessment; biotic ligand models have been developed for a number of metals (e.g., zinc), and these should be considered in the assessment as well. Finally, the assessment approach seems to use a sum TU-based approach for assessing "metals mixture" impacts. This is based on an assumption of additive interactions among the metals. Although this is probably the best assumption in going forward, limited data are available to support this approach.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to potential failure of water and leachate collection and treatment from the mine site.

I am not an expert on salmonid fish and cannot provide any further information in the forms of literature, reports and data not referenced that would be useful to characterize these risks.

Phyllis K. Weber Scannell, Ph.D.

This section of the report provides a thorough discussion of possible sources and fates of contaminated water. Chapter 6.3 discusses possible adverse effects from early mine closure or prematurely shutting down a water treatment system. These issues highlight the need for a mine plan that includes concurrent reclamation, sufficient bonding to conduct reclamation in the event of an early shut down and plans and specifications for collection and bypass of clean water and collection and diversion to a water treatment system of contaminated water.

The Risk Characterization (Section 6.3.3) presents an in-depth discussion of possible contaminant loads to downstream waters. As stated in this section, it "serves to indicate the large potential risk from improperly managed waste rock leachate." This statement highlights the need for an in-depth mine plan with sufficient monitoring and fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized.

Paul Whitney, Ph.D.

No comment.

Question 7. Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The description of culvert failure is necessarily general because there are currently no designs. General data on culvert failures indicate a high probability (30-66% failure rate). I have not reviewed these papers, so I do not know the nature of the roads included in the referenced papers. It is probable, however, that the transportation corridor for the project would be constructed to a higher standard than most of the roads included in the papers. It would be helpful to know if similar data are available for highly engineered roads of the type likely to be built for the project.

Steve Buckley, M.S., CPG

The references provided in this section emphasize culvert failures in the Pacific Northwest and Tongass National Forest. The streams and culverts in these regions are heavily influenced by large woody debris loading. It would be more appropriate to classify the various potential stream crossings by watershed and the amount of large woody debris available to be recruited to the stream and influence culvert blockage.

Courtney Carothers, Ph.D.

Culvert failures due to blockage and erosion are noted to be common and are likely to occur in this scenario. Culvert failures would prevent the movement of fish, which could eliminate a year class from blocked stream systems and fragment upstream and downstream populations, increasing likelihood of localized population depletions and extinctions. Monitoring and maintenance of culverts can be expected to decrease after mine operation, increasing the risks of these failures. The report appears to appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

Mitigation practices, such as new culvert design, was well described as was bridging of roadways and porous fills to mitigate risks due to culvert failure along the transportation corridor. This assessment also included appropriate risk characterization for both the no-failure and failure scenarios. No suggestions for improvement. There may be literature available from the WA State Department of Transportation, who has conducted recent studies on fish passage relative to culvert placement and design.

Gordon H. Reeves, Ph.D.

The literature review of culverts and their potential impacts fish and fish habitat is very thorough and the presentation of results is accurate. However, I think that there are potential mitigation measures that were not presented. The primary one, besides the use of bridges, as suggested in the report, is that all culverts be arch culverts. These culverts make use of the stream bottom, which reduces the potential for the culverts to become perched and impede upstream movement, and are less likely to change the gradient than other culvert types.

All culverts could, as recommended in the report, be at least one bank width, which is larger than required by the state of Alaska. This would minimize the possibility of plugging with debris.

The review of potential road impacts lacked two possible consequences. One is that roads could be corridors for the introduction of invasive species, plants and animals. The consequences of the successful establishment of non-native species could have critical ecological impacts on native species and the ecosystem. The second consequence is that a road will allow greater access to streams where access was previously limited. Fish populations could be more easily and intensively harvested in sport and subsistence fisheries, which adds additional stresses to the populations. Lee et al. (1997. Assessment of the condition of aquatic ecosystems in the Interior Columbia River basin. Chapter 4. Eastside Ecosystem Management Project. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.) found a direct relation between road access and the status of salmonids populations in the Columbia Basin.

Charles Wesley Slaughter, Ph.D.

No. The Assessment does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings is a major concern for aquatic habitat and fisheries. Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.

The specific consequences of a failure on salmonid habitat and biology are portrayed well.

John D. Stednick, Ph.D.

No. It is unclear how the estimate of 50% of the culverts would fail, given that the literature shows a range of 30 to 60% (Section 4.4.4). What literature was used? Are road BMPs satisfactory in this environment? Have the Alaska BMPs been audited? Culvert repair taking a week to several repairs in a month seems high. If the road crosses a critical salmon rearing stream, conservative pipe sizing or bridgework could be considered. The direct loss or inaccessibility of upstream salmon habitat does not necessarily translate to salmon loss. Timing of a culvert blocking event with salmon migration and duration of blockage should be considered.

What are the design considerations for the culverts? What precipitation/streamflow relationships will be used for sizing purposes? What are the usual casual mechanisms for culvert failure? How much woody material do these streams carry? Do culverts fail from debris plugging, road slumps, or overtopping by storm events? What road BMPs will be implemented?

Roy A. Stein, Ph.D.

Sizing Culverts: Page 5-61. Here the suggestion is that "Culverts must be 0.9 times the ordinary high-water width…" and where the channel slope is less than 5%, the "the culvert is allowed to be 0.75 times" this same metric. Does this take into account global climate changes which would mean higher flow rates than historically has been the case? Shouldn't culverts be sized larger than what historical flow rates would suggest, given that Climate Change will likely result in more intense storms and therefore greater stream flows than has historically been the case?

Culvert Failures: Page 6-42. Culvert failure rates of 30-66% suggest we are doing something wrong with establishing these culverts to maintain stream flow under a road. How might we reduce this rate of failure (larger culverts? placement issues? solutions of any sort?)? In fact, if indeed 50% of the culverts will be blocked (see bottom of page 6-43), are we not dealing with an unacceptable solution of running streams under roads? Might there be some replacement of these culverts with bridges; certainly, bridges are more expensive to build but they simply do not have the failure (re blockage) rate that culverts do. Might there be a trade-off here between initial investment costs (high for bridges) and salmon protection (fewer blockage events)?

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to culvert blockage and failures. Culvert blockages will prevent salmon passage leading to possible effects on reproductive success. Literature data for the incidence of culvert failures were used in assessing failure probability. This seems to be an appropriate approach given the hypothetical nature of the mine used in the assessment. I am not aware of additional data that should be considered.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to culvert failures along the transportation corridor. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to culvert failures along the transportation corridor.

I am not an expert on salmonid fish and cannot provide any further information in the forms of literature, reports and data not referenced that would be useful to characterize these risks.

Phyllis K. Weber Scannell, Ph.D.

The risks to salmonid fish due to culvert failures would be minimized by implementation of permits by Alaska Department of Fish and Game (ADF&G), Habitat Division. Under A.S. 16.05.840-870, Alaska has some of the most protective laws for fish and fish habitat in the United States. Every road crossing in fish bearing waters (either anadromous or resident fish) requires a permit from the Habitat Division. The permit will contain plans and specifications to ensure the free passage of fish. Should a fish crossing fail (i.e. culvert blockage, washouts, etc.), the applicant would be in violation of the permit and required to remediate the crossing. There have been several instances of culvert failures that required the applicant to install a bridge. In other cases, an applicant has asked for a permit to install a culvert, but, upon review by Habitat Division, a bridge was required.

The statute states:

> Sec. 16.05.841. Fishway required.
> If the commissioner considers it necessary, every dam or other obstruction built by any person across a stream frequented by salmon or other fish shall be

> provided by that person with a durable and efficient fishway and a device for efficient passage for downstream migrants. The fishway or device or both shall be maintained in a practical and effective manner in the place, form, and capacity the commissioner approves for which plans and specifications shall be approved by the department upon application. The fishway or device shall be kept open, unobstructed, and supplied with a sufficient quantity of water to admit freely the passage of fish through it. (http://www.legis.state.ak.us/)

A second statute, The Anadromous Fish Act (AS 16.05.871- .901) pertains only to anadromous fish, not resident species. The Anadromous Fish Act "requires that an individual or government agency provide prior notification and obtain permit approval from ADF&G before altering or affecting 'the natural flow or bed' of a specified waterbody, or fish stream. All activities within or across a specified anadromous waterbody require approval from Habitat, including construction; road crossings; gravel removal; mining; water withdrawals; the use of vehicles or equipment in the waterway; stream realignment or diversion; bank stabilization; blasting; and the placement, excavation, deposition, or removal of any material." http://www.legis.state.ak.us/

Under these statutes, culvert failures that impeded the passage of fish altered the stream bed or degraded fish habitat would not be allowed.

Paul Whitney, Ph.D.

<u>Criteria for bridge versus culvert installations along the proposed road.</u> The dynamic process of beaver dams causing streams to move across the floodplain should also be a criterion for determining if and where culverts are installed for a potential road (pages 4-36 and 4-63). Even if salmonids are not present at a stream crossing, the mosaic of active and decayed beaver ponds in the floodplain can be important rearing areas for forage fish and benthic drift that are utilized by salmonids (Snodgrass and Meffe, 1997; Schlosser and Kallemeyn, 2000). If beaver dams (but not salmonids) are present above proposed stream crossings, bridges or causeways that allow the streams to move across the floodplain should be recommended versus a culvert.

Spills of transported chemicals are not quantified in the culvert failure section of the assessment. I have participated in a mine risk assessment and a landfill risk assessment where spills of cyanide and landfill leachate have been modeled. While I did not conduct the plume movement analyses, stream hydrologists readily calculated how far spilled materials would move down stream until the concentrations of chemicals in streams reached acceptable benchmarks. The consequence of a cyanide spill on aquatic resources is acute and far reaching but short lived. Given the possibility of a heap leach processing facility (see response to question 2) at the mine site, a cyanide spill on the haul road should be addressed. In addition, the longevity of a spill of processing chemicals for copper processing should be calculated. It appears that the Water Treatment failure assessment on page 6-39 conducted some sort of plume analysis to determine the potential for an impact on Illiamna Lake. Perhaps it is possible to use this analysis or at least the model to address the consequence of a spill of transported chemicals.

Question 8. Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The discussion of pipeline failures is based on published failure rates, principally for oil and gas pipelines. This analysis results in a pipeline failure rate of one per 1,000 km per annum. This is a pretty generic number that does not consider actual pipeline design. Rather, it indicates that pipelines designed using standard practices do fail with a fairly high frequency.

A concentrate pipeline spill would have differing impacts depending on when and where the spill occurred, with deposition in Lake Iliamna likely being the worst outcome. As noted in the report, it is likely that a pipeline spill would be detected rapidly and that the volume of the spill would be limited and amenable to remediation.

Steve Buckley, M.S., CPG

The assessment does generally characterize the risks to fish from pipeline failures.

Courtney Carothers, Ph.D.

A pipeline failure would be expected to release toxic leachate into streams systems in the transportation corridor, none of which would dilute the leachate enough to prevent severe toxic effects (both immediate and long-term). The report discusses three pipeline failures in the Bajo de la Alumbrera mine in Argentina. The largest pipeline failure lasted two hours (compared to only two minutes of exposure hypothesized in the current mine scenario). The report could more clearly describe this case and its likely effects. The report appears to appropriately characterize risks to salmonid fish due to pipeline failures, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

The risks to salmonid fish due to release of pipeline concentrate/slurry and leachates (as return water) are well described. However, risks of a diesel fuel spill are not. More detail could be provided on reclaimed water. For example, what toxic constituents (and at what volumes) would be released to the environment if these pipelines failed?

Gordon H. Reeves, Ph.D.

Assuming that characterizations of the pipeline failure are accurate, the potential impacts on fish and fish habitat are appropriate and reasonable. It was clear that the effects of a pipeline failure could be major, depending on the duration of the spill, because of the concentration of metals in the slurry and the reduced potential to fully remove the material from a stream or wetland afterwards.

The one question that I had about this section was the potential impact on phytoplankton and zooplankton in Lake Illiamna, particularly at the local scale. I assume that any spill from pipeline failure would have potential impacts on the lake and on phytoplankton and zooplankton, the major food for juvenile sockeye salmon. The ecological consequences would depend on how wide spread and the intensity of any spill was and on how juvenile sockeye use areas near tributary streams. I would expect that a spill could be particularly detrimental if juvenile sockeye use the area near or adjacent to natal streams when they enter the lake. I think this should be considered in more detail in any additional analysis.

Charles Wesley Slaughter, Ph.D.

No. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. On-site investigation may well reveal many more "watercourses" (including intermittent and ephemeral streams), than the 70 crossings cited; possible pipeline failures thus may have much wider potential for impacting salmonids than is indicated in the Assessment.

The "probability" argument of p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there would be only 1.5 stream-contaminating spills, or two wetland-contaminating spills, over 78 years of operation seems wildly optimistic (and what is half a spill?).

Assuming that any spill (over the 78-year project span) would last only two minutes (p. 6-32, 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus. The authors appear to recognize this with their discussion of the Alumbrera incident.

The specific **consequences** of a failure on salmonid habitat and biology are portrayed well.

John D. Stednick, Ph.D.

The pipeline corridor consists of 4 pipelines over a distance of 86 miles. No information was provided on pipeline structure or placement, other than mentioning of stream crossings. The pipeline failure of concentrate slurry was modeled using chemistry from the Aitik (Sweden) mine, is this best approximation? That mine is about 80 years old and is processing ore from the edge of the pit, with much lower sulfur content than Pebble.

Pipeline failures can be significant in any environment, so spill or pipe break prevention requires significant monitoring. Will automatic shutoff controls be included? Workers are stationed 24 hours/day every day? Some of the past Alaska failures were in winter conditions, when things were not easily visible--under ice or snow cover. How will this be addressed?

The toxicity approach seems reasonable. What is the anticipated chemistry of the return waters? Diesel spill monitoring? The geometric mean of three values (which references) is that there is a 14% probability of failure in each pipeline each year. This is not acceptable at any level.

Roy A. Stein, Ph.D.

Pipeline Failures I. What dictates 14 km between automatic shut-off valves; shouldn't this distance be shorter as the pipe becomes larger, i.e., related to the amount of liquid/slurry that would be spilled upon pipe failure?

Pipeline Failures II. Like all other failures, it seems to me that "Standard Operating Procedures (SOP)" for mitigation should be in place in anticipation of any future spill or contamination of the environment. I do not think that these procedures need to be in this report but an acknowledgement of their presence and that mining companies will follow these SOPs in response to any spills that occur, be it pipeline, TSF, truck, leachate bed, etc.

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to potential pipeline failures as part of the risk assessment. This evaluation focused on potential failures associated with the pipelines for the product concentrate slurry and return water. No consideration of the natural gas or diesel pipelines was presented, stating that such pipelines "are common and the risks are well-known." Although I would acknowledge the failures in natural gas and petroleum pipelines are common, I would not discount the potential effects to salmon populations associated with such spills. Evaluation of potential impacts due to a spill of product concentrate slurry or return water was based on extant data from an existing copper mine in Sweden; to the extent that this slurry and return water is representative of similar materials coming from the Pebble mine, this approach is appropriate. The assumptions used in the amount of material that might possibly be spilled seems appropriate and based on past experience and realistic assumptions; however, these assumptions need to be reconsidered if and when a real mine plan is prepared.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to pipeline failures. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to pipeline failures.

I am not an expert on salmonid fish and cannot provide any further information in the forms of literature, reports and data not referenced that would be useful to characterize these risks.

Phyllis K. Weber Scannell, Ph.D.

This section of the document focuses on effects of pipeline failures; however, without a viable mine plan, it is not certain that any pipelines will be constructed. The resource developer may opt to build a pipeline to transport fuel from the coast to the mine site or slurry concentrate to the port. Construction of any pipelines would require review and approval by state and federal agencies, such approvals would likely contain monitoring plans to ensure pipeline integrity.

Paul Whitney, Ph.D.

See responses to Charge Questions 2 and 7.

Question 9. Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The Assessment generically describes tailings dam failures and the potential impact in detail. It also uses some site-specific information on tailings supernatant and humidity cell leachate. There is no question that a tailings dam failure would be catastrophic for the fishery and the project, and is the single largest risk to the fishery. A tailings dam failure could irreparably harm a very large area of the watershed for a very long period of time without a massive and expensive remediation effort.

The tailings deposition and storage methods outlined in Ghaffari et al. 2011 and in the Assessment are conventional for the industry and comply with Alaska State regulations. These types of impoundments do fail with some frequency as described in the report.

Because of the dire consequences of a failure in this highly sensitive and unique environment, it would be necessary to employ state of the art methods for tailings management and go 'beyond compliance' when designing and constructing this facility. This may include employing methods that are novel, incur significant additional cost for construction, and lead to a more stable and lower maintenance facility in the long term, such as paste rock tailings (blending waste rock in with tailings in the impoundment to provide extra geotechnical stability). These methods, however, are not common practice and are still under development.

Steve Buckley, M.S., CPG

The assessment does generally characterize the risks to fish from tailings dam failures.

Courtney Carothers, Ph.D.

In the event of a tailings spill, invertebrates and fish would be exposed to toxic tailings and leachate. Actual tailings failure examples suggest the range of exposure would spread to an area more than 100 km. Copper would be especially toxic to invertebrates, fish eggs and larvae. Toxicity would last for decades. The report appears to appropriately characterize risks to salmonid fish due to a potential tailings dam failure, although I have no particular expertise with which to evaluate this assessment.

Dennis D. Dauble, Ph.D.

Tailings deposition is described in Chapter 4 of the main document, but I could not find anything that described potential risks to fishes, including effects to aquatic food webs and loss of fish spawning and rearing habitat. As noted in the text, the sediment transport model used could only simulate sediment transport and deposition about 30 km downstream of the mine site. Thus, potential effects to fish habitats were not well quantified for the mainstem Koktuli River (and beyond), in addition to the Mulchatna and Nushagak rivers.

The assessment deemed that it was "not possible" to determine how far the initial slurry deposition would extend, how far re-suspended sediments would travel, and how long erosion processes would continue. It seems to me that something more could be conjured up based on information from other mine closure sites used by assessment authors to infer effect by analogy. The statement alluding to potential sediment runout distance at the bottom of page 4-56 of the main document should be included in the summary of effects. This is an important point.

Gordon H. Reeves, Ph.D.

Assuming that characterizations of the dam failure are accurate, the potential impacts on fish and fish habitat are appropriate and reasonable. Impacts, like those of a pipeline failure, are likely to be wide spread in the watershed and to be long lasting and result from inundation of areas by sediments and contaminants the water. I think that potential impacts across the broader scale could be developed and highlighted more fully. Also, consideration of Intrinsic Potential (see answer to Question 4) could provide additional insights into potential impacts of a tailings dam failure.

I think that potential consequences of climate change on hydrographs should have been considered in this section. More precipitation is projected to occur as rain in the winter rather than snow for many parts of AK. How would this potentially impact the tailings dam facilities? This seems to be a key piece of information that is needed to better understand the risk of dam failure and the potential for impacts on aquatic resources.

I thought that results to date of the impacts of the volcanic eruption at Mt. St. Helens, while not exactly the same as a mine operation, were useful in considering long-term impacts and the response of aquatic ecosystems to such major disturbances. However, I think that the impacts on streams are still more prevalent and extensive than what is described in the report. Most stream systems are still transporting large amounts of fine sediment and areas of exposed gravels are rare.

Charles Wesley Slaughter, Ph.D.

Yes. Physical consequences of TSF dam failure are fairly portrayed; I would only suggest that effects of initial sediment deposition and long-term remobilization and redeposition would extend beyond the spatial and temporal limits of the modeling used in the Assessment.

Employing advanced eco-hydraulic modeling tools such as MIKE-11 (DHI, Copenhagen), and consultation with state-of-art practitioners (IAHR, Center for Ecohydraulics Research, and others), along with improved high-resolution input data such as LIDAR survey of the complete Kvichak and Koktuli/Nushagak systems, would allow a more complete estimate of potential hydrologic and sedimentation (and consequently biotic) consequences of TSF dam failure for the entire river system, headwaters to Bristol Bay.

John D. Stednick, Ph.D.

The modeled tailings dam failure used an estimate of 20% mobilization from the tailings ponds. How was this value determined? The model was run to a stream length of 30 km (the rivers confluence), yet the report acknowledges that a sediment pulse could run for hundreds of km. The risk assessment is an academic exercise, but no better alternative is available. The moisture content of the tailings is estimated to be 45% by volume (page 4-50), the 20% volume of sediment may be underestimated.

The PMP (probable maximum precipitation) value was extrapolated from Miller (1963) and the assessment commented how this value might be reduced upon further analysis. Conversely, additional data could increase this value. There was no discussion of the recurrence interval of this 24 hour storm.

No hydrologic data were provided. The streamflow gauging stations operated by the U.S. Geological Survey near the study area, suggest peak streamflow rates from snow melt and from rain events. The hydrograph shape and magnitude help determine if rain or snowmelt dominated. In the assessment, the peak flow estimate from the NRCS runoff method used a Type 1a storm distribution, the least intense precipitation distribution, and the literature would suggest that a Type 1 distribution would be more appropriate for Alaska. How does this storm event compare to the measured flood at Ekwok (page 4-50)? The curve number (CN) was not identified, nor the methods used to calculate that value. Similarly, the watershed slope, time to peak, hydraulic length, channel routing functions, and channel resistance methods or results were not presented. What precipitation data are available? Design of culverts, bridges, and storm water ponds, all require good precipitation records and the confidence in that estimate is based on record length.

The relation of groundwater flows to streamflow during storm events needs to be evaluated. The flood producing precipitation events in this area no doubt add to groundwater flows.

With a new estimate of precipitation depth of known recurrence interval, the design storm could result in a higher flood event with greater velocities, sediment transport ability, and sediment volume released from the TSF, resulting in a greater risk to salmonid fish and habitats.

Roy A. Stein, Ph.D.

TSF Failure and Remediation. The text on pages 6-1 to 6-2 states:

> "Remediation may occur following a tailings spill, but it is uncertain. A spill would flow into a roadless area and into streams and rivers that are too small to float a dredge, so the proper course of remediation is not obvious."

At this juncture in time, this statement points to the fact that we do not have the technology, or the appropriate operating procedures, in place to remediate a TSF spill. Does this essentially let the mine operator "off the hook"? Should we be promulgating mining activities in locations where we cannot remediate spills, given our current state of knowledge or ability to apply current techniques?

William A. Stubblefield, Ph.D.

Potential effects on salmonid populations were evaluated due to tailings dam failures. Tailings dam failure would potentially result in the release of large volumes of mine tailings and associated contaminated waters leading to possible acute and long-term effects on salmon populations. It is also important to note that direct effects on salmon may be very species dependent, due to life-cycle differences, and the time at which the dam failure occurs. Potential effects due to sediment inundation/impaction can adversely affect habitat leading to decreased spawning. Evaluation of the potential for tailings dam failure effects considered acute and chronic risks due to aqueous exposures, chronic risks due to sediment exposures, and risks due to dietary exposures. All of these seem to be appropriate exposure pathways and all were adequately considered, although site-specific information will improve risk predictions.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to salmonid fish due to a potential tailings dam failure. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to salmonid fish due to potential tailings dam failure.

I am not an expert on salmonid fish and cannot provide any further information in the forms of literature, reports and data not referenced that would be useful to characterize these risks.

Phyllis K. Weber Scannell, Ph.D.

The assessment considers two possible failures of the tailings dam: a partial-volume failure occurring during mine operations and a catastrophic failure, occurring during or after mine operations. The partial-volume failure (as modeled in the assessment) would result in a greater than 1,000-fold increase in discharge and the catastrophic failure in a greater than 6,500-fold discharge.

The discussion of tailings dam failures describes possible changes in channel and floodplain morphology and briefly mentions that the tailings deposition would be a source of easily transportable, potentially toxic material.

The potential for increased metals loadings to river and lake systems is understated. Although there are no current predictions of tailings water quality, the water quality of tailings water from similar mines could be used to model increases in metals loading from dam failures.

In addition to the partial-volume failure and the catastrophic failure, there are other possible sources of metals loadings from the tailings pond. Examples are emergency releases of untreated tailings water, seepage of tailings water into the groundwater and flow from the tailings pond to groundwater in an adjacent drainage as the head (i.e. hydrostatic pressure) is increased as the tailings pond is filled. The last example was experienced at the Red Dog Mine when the increased elevation of the tailings pond caused water to flow underground into the Bonns Creek drainage instead of the Red Dog Creek drainage. Interception ditches were installed after the increases in metals loading to Bonns Creek were detected.

Paul Whitney, Ph.D.

I agree with the assessment that it would take a "very long time" (page 6-25, first full para, last line) to reach concentrations that would not exceed threshold exposure levels. A "very long time" could mean hundreds of years to one person or geological time (i.e., millions of years) to another person. The assessment could be improved if some sidebars are put on the time likely required for no risk dilution or "more normal channel and floodplain". One suggestion would be to estimate the amount of time it would take the river/stream to move across the floodplain in the "relatively undisturbed" Bristol Bay watershed. I would also like to know whether reclamation or rip rap in areas with spilled tailings would reduce or extend the time to reach "more normal" conditions.

Question 10. Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

David A. Atkins, M.S.

The assessment does a good job analyzing the importance of fish resources to other wildlife and to Alaska Native communities. The lack of site-specific information in the report results in only very general conclusions that there 'would be some effect'. Of course, wildlife in the *project area* and any traditional use of these lands would be affected by project construction under the no-failure scenario. However, due to the lack of information it is unclear if this is an area rich in other wildlife or if there are traditional native land users that rely on the area. Although the conclusion of this section is necessarily general, it would be helpful to have a more detailed characterization of wildlife and native use in the project area.

Under the failure scenario, a tailings dam failure, in particular, would be catastrophic for wildlife and Alaska Native communities that use the area.

Steve Buckley, M.S., CPG

The assessment does generally characterize the risks to fish, wildlife and human cultures from catastrophic tailings dam and pipeline failures.

Courtney Carothers, Ph.D.

Wildlife: The sections discussing risk to wildlife resulting from effects on salmonids are fairly short. Those animals that directly feed on these fish are likely to be impacted, as well as those that depend on other resources enhanced by the marine-derived nutrients supplied by salmon carcasses. The report concludes that the primary aquatic contaminant is copper (5-75), but notes that the ore processing chemicals are unknown, as are their toxicities (5-59). These unknowns could be noted as potential contaminants.

Human cultures: Overall, the main report (and Appendix D) describes the central role that salmon play in both Yup'ik and Dena'ina culture, both traditionally and in contemporary communities. As noted above, the scope of the assessment focusing on these two cultural groups should be made more clearly. Appendix E, for example, focuses on other human groups local to this region, and those who migrate to the region for commercial fishing and recreation who may also be affected by risk to fish in this region. The vulnerabilities listed in Appendix D (pp 4-5) could be listed in the main report more clearly as risks.

Literature on the effects of contaminated or declining resources on subsistence communities could be utilized to describe, in more detail, likely impacts. For example, the report notes: "the actual responses of Alaska Native cultures to any impacts of the mine scenario is uncertain" (ES-26). While the specific responses are uncertain, likely responses can be predicted (and many are articulated in Appendix D). There are data on the psychological, social, cultural, and economic disruptions caused by the Exxon Valdez oil spill (e.g., Braund and Kruse 2009; Palinkas et al. 1993), the cumulative effects of oil and gas development in the North Slope region (e.g., Braund and Associates 2009; NRC 2003), and social impacts related to mining development in Alaska (e.g., TetraTech 2009; Storey and Hamilton 2004). Drawing on some of this literature could help provide likely scenarios for impacts to Alaska Native subsistence-based communities from decreased quality, quantity, or diversity of salmonids. Current and recent responses to salmon shortages in the Yukon-Kuskowkim region may also be helpful to include.

Clearly the impacts to subsistence are not just lost food sources, but lost lifeways, loss of practices, loss of cultural connections to the past, loss of connection to specific places, loss of teaching and learning, loss of sharing networks, loss of individual, community, and cultural identity, among others as detailed in Appendix D. This point could be made more forcefully. As noted above and detailed in the specific comments below, the subsistence is framed at times in the report as primarily ones of physical health and economic necessity. The livelihood, cultural, social, psychological, and spiritual impacts should also be consistently highlighted.

As discussed Appendix D, Alaska Native cultures in this region and other regions in the state are also dependent upon the cash economy, both for subsistence production and for other needs. The role of commercial salmon fishing or other wage engagements related to salmon in the study communities, while discussed in Appendix E, is not given much discussion in the main report. How dependent is the subsistence economy upon commercial fisheries in this region?

There is a brief mention of non-fish related impacts to Alaska Native communities in the main report (5-77). Unless a full treatment of these impacts (positive and negative) is included, these paragraphs should be removed. While in general, I am supportive of an increased scope (e.g., it is difficult to isolate only salmon-mediated impacts to Alaska Native communities), these other economic, social, and cultural impacts are not presented fully in the analysis, nor was the ethnographic research designed to investigate these impacts, so mention of them here does not seem appropriate.

Dennis D. Dauble, Ph.D.

There is considerable information in appendices D and E on impacts to the economy. This detail includes how salmon affect all segments of the population, including cultural resources of Native Peoples. Wildlife and their ecological dependencies are also well-characterized. Not addressed in detail were long-term impacts to Native Peoples that might occur after losing a way of life that includes salmon. The description of potential impacts to their health and welfare should be expanded. There are numerous examples of how Columbia River tribes have been negatively impacted due to loss of fish resources (and fishing as a lifestyle) as a result of dam construction. These impacts go beyond simple economics.

Gordon H. Reeves, Ph.D.

These topics are outside my area of expertise so I cannot comment on if the report adequately characterizes the risk to wildlife and human cultures. I am familiar with some of the literature on the importance of salmon to wildlife and the report represents the finding fairly and accurately. I cannot provide any additional literature, reports, or data.

Charles Wesley Slaughter, Ph.D.

No. The Assessment clearly qualified that its objective was to consider risks to salmonids, and only inferentially consider "salmon-mediated" effects.

Appendix C provides a comprehensive discussion of non-fish wildlife and the relation of those populations to salmon. However, the Assessment itself (Volume 1) provides only a brief summary in Chapter 2.2.3, which could allow a cursory reader to perhaps conclude that wildlife populations have little risk of impact from the hypothetical Pebble project. Is this the intent of the Assessment authors? A more in-depth reading of Appendix C allows inferring potential consequences to wildlife and birds of "salmon-mediated" impacts of mining development.

Appendix D provides a comprehensive and useful discussion of the indigenous people of the Bristol Bay region, and of their traditional ecological knowledge and cultures Appendix D clearly lays out the vulnerabilities and risks – summarized in pp. 4-5 and 150-153 – associated with the (hypothetical) major resource extraction projects. However, the Assessment (Volume 1) provides only cursory consideration of these human aspects of the potential project, on p. ES-23, and in Section 2.2.5. Presumably this is because the EPA mandate is to conduct an ecological risk assessment, rather than assessment of consequences for human populations, whether indigenous, native, resident, non-native, non-resident, or the larger cash economy world as represented by the State of Alaska, Northern Dynasty Minerals, or Pebble Limited Partnership.

John D. Stednick, Ph.D.

The effect on wildlife section largely focuses on the return of nutrients to the land in various shapes and forms and adds little to the discussion. What are the consequences of the mine operation on other wildlife habitats? Habitat fragmentation? Noise and light disruptions, etc?

The importance of salmon as human nutrition is well recognized and the potential loss or change in lifestyles of indigenous peoples seems to be relegated to Appendix D. Bring more of this information to the forefront of this discussion.

Roy A. Stein, Ph.D.

Risks to Wildlife. The importance of salmon in bringing Marine Derived Nutrients (MDN) into these freshwater ecosystems and watersheds and their role in influencing wildlife and associated interactions between wildlife and human cultures was well described. Loss of these nutrients would severely compromise wildlife, and thereby human (through reductions of subsistence harvest), populations.

Risks to Human Cultures. I thought that the assessment could be approved if the same approach used for the mine, i.e., a case history approach, was used for human cultures. Surely, there exist situations where salmon have declined or have been reduced by development/exploitation (the Fraser River, perhaps?) where subsistence by Native Alaskans was historically paramount. Once the salmon were reduced, what was the impact on the Native Alaskans subsistence culture? How did the Native Peoples respond? From whence did they get sustenance, cash, etc.? What sort of displacement occurred?

William A. Stubblefield, Ph.D.

Potential effects to wildlife and human cultures are briefly addressed in the risk assessment. No "quantitative" assessment of potential effects is provided. For the most part, it appears that potential affects to both wildlife and human cultural endpoints are directly proportional to the injury suffered by salmon populations as a result of any spills or failures. Given the level of detail available at this point in time regarding mine operations and closure, that is probably about as far as any assessment could go. I'm not aware of any literature reports or data that would assist in further characterization of these potential injuries.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify or appropriately characterize the risks to wildlife and human cultures due to risks to fish. It only estimates the likelihoods of occurrence and the consequences. See discussion under Question 4 above regarding suggestions for improving estimation and expression of the magnitude of risks to wildlife and human cultures due to risks to fish.

I am not an expert on wildlife and human culture and cannot provide any further information in the forms of literature, reports and data not referenced that would be useful to characterize these risks.

Phyllis K. Weber Scannell, Ph.D.

The document focuses on effects to wildlife that would occur from failures – tailings dam failure, pipeline failure, etc. There are other sources of disturbance to wildlife that should be addressed in a future mine plan and agency review and permitting. Other mines in Alaska limit truck traffic on the haul road during caribou migrations, incinerate all kitchen waste, educate workers on bear safety and prohibit inappropriate disposals of food containers or other wildlife attractants. Other factors that might need to be addressed to protect wildlife are limiting air traffic and noise during certain times of the year. Unless addressed, these issues are more likely to cause detrimental effects to wildlife than dam or pipeline failures.

Addressing issues related to effects on human cultures is outside my area of expertise.

Paul Whitney, Ph.D.

If one addresses this question at face value, the answer is pretty straight forward. The assessment tells us that the consequences of loss and degradation of habitat on fish populations could not be quantified because of the lack of quantitative information concerning salmon, char, and trout populations (page ES-26, third bullet). Furthermore, we learn that indirect effects such as risks to wildlife cannot be quantified (page 5-75, para 1, last line). Stating that reduced salmon production would reduce the abundance and production of wildlife (page 5-75, para 1, last sentence) is accurate but not appropriate for a document that is intended to provide a scientific and technical foundation for future decision making (page ES-1, para 1, last sentence). It is certainly possible to provide a more complete scientific and technical response to question 10. I respectfully suggest that the first step in developing a more complete scientific and technical response is to modify the question by deleting the words "due to risks to fish" and to separate the risks to wildlife and human culture. A revised wildlife question should address both indirect and direct risks. A revised human culture question should address both direct and indirect risks to fish and wildlife.

The assessment and questions given to the review committee give mixed messages regarding the scope of work. A variety of statements and conclusions in the assessment are inter-related as one would expect for a document that addresses ecosystem issues. While acknowledging the overlapping issues and responses, I offer the following discrete points that give me mixed messages regarding the scope of work and an appropriate characterization of risks to wildlife.

1. The PREFACE (para 2) clearly states "Our goals in conducting this assessment are to complete an objective assessment of the potential impacts of large scale mining on aquatic resources in the Bristol Bay watershed." This statement is subject to wide interpretation by this reviewer and by the document itself. The lack of clarity in the goal statement is problematic. One can readily understand that timing and budget constraints result in some statements indicating that data is just not available, or that certain types of modeling, while possible, were not conducted. However, it is difficult to understand why potential impacts to wildlife are limited to indirect effects due to loss of fish if the assessment was truly conducted as an ecological risk assessment (Abstract, line 5). One of the first things an ecological risk assessment does is to state well defined endpoints. Suter (1993, page 22) presents 5 criteria that any endpoint should satisfy. My notes are in brackets.
    a. Societal relevance (Assessment appears to do a good job of identifying concerns of people living near the area of the proposed mine. Yet, many of the potential endpoints listed in Figure 3-2E are not addressed. The reason for not assessing topics such as wildlife quality and quantity should be provided.).
    b. Biological relevance (The biological – especially ecological - relevance is incomplete. Wildlife are relevant in that they comprise a large majority of the secondary and tertiary consumer species in the ecosystem. The upland and aquatic habitats utilized by wildlife are the sources of many nutrient and energy inputs to the salmon ecosystem. The upland components of the Bristol Bay ecosystem should be assessed in more detail to provide a biologically relevant assessment. If not, the assessment should directly indicate why not.
    c. Unambiguous operational definition (Overall a good job. See response to Charge Question 2 for a few suggestions).
    d. Accessibility to prediction and measurement (The inability to estimate the impact on salmon numbers is problematic. Is the inability due to a lack of population data, the unwillingness to utilize peer-reviewed methods other than demographic population modeling or some other reason? Furthermore, the inability to assess the loss of marine derived nutrients on wildlife can be assessed – see below.
    e. Susceptibility to the hazardous agent (Assessment does a good job on the hazards for aquatic resources but not susceptibility to wildlife and abiotic changes (e.g., ice dams and scouring, as well as hydrographs and sedimentation influence on ecological succession).

    Suter's five criteria should be addressed. The lack of an estimate of the impact on salmon, wildlife, as well as community and ecosystem parameters, should be remedied.

2. A complete assessment of aquatic resources, as stated in the PREFACE, should address both direct and indirect risks to the many species of wildlife and wildlife habitat that are

aquatic resources and closely associated to aquatic resources. The list of all the aquatic species and habitat is lengthy. A partial list of categories of wildlife and wildlife habitat that are aquatic resources includes grebes, ducks, shorebirds, beaver, muskrat, otter, mink, riparian, emergent and aquatic vegetation. The impact of mining on all these types of aquatic resources is given scant coverage in the assessment with the possible exception of impact to wetlands. The PREFACE gives me mixed messages from the start.

3. The Executive Summary (para 1) indicates "…USEPA launched this assessment to determine the significance of Bristol Bay's ecological resources and evaluate the potential impacts of large-scale mining on these resources." The emphasis on salmon does not fairly represent ecological resources. To me, ecological resources should include ecological parameters such as plant community succession, species diversity, energy flow, and structure and function, in addition to the information on a few salmonids.

4. The Scope of the Assessment (ES-1 last para) indicates that "wildlife … as affected by changes in the fisheries are additional endpoints of the assessment." This informs the reader that only wildlife species that are affected by changes in the fisheries will be an endpoint. Yet many species of wildlife that are affected by changes in the fisheries are not addressed. In addition, such an endpoint glosses over the importance of fisheries that are affected by changes in wildlife such as the beaver (habitat modification) and gulls/terns (predation). The Scope of the Assessment seems to brush over many of the important fish and wildlife interactions discussed by Cederholm et al. (2000) and Cederholm et al. (2001) and focuses mainly on marine derived nutrients. I am pleased with the discussion of the marine derived nutrients but am not clear how the emphasis on this one interaction, which is not quantified in the assessment, furthers the understanding of potential mining impact. Gende et al. (2004) use a variety of methods to quantify both the marine derived nutrients and energy that transfer from salmon to terrestrial wildlife and habitats. For example, they determined that bears moved nearly 50% of the salmon-derived nutrients and energy from streams by capturing salmon and dragging the carcasses from the stream. Gende has also worked with University of Alaska Associate Professor Mark Wipfli (Gende et al. 2002) on the relationship of salmon to terrestrial habitats. Alaskan and national experts are likely available to assist EPA in quantifying the movement of marine derived nutrients to the terrestrial ecosystem.

5. As mentioned above, the assessment does a fine job of emphasizing the importance of marine derived nutrients transported to the terrestrial environment but has relatively little information on the importance of terrestrial derived allochthonous nutrients transported to the aquatic environment. Doucett et al. (2007) discuss methods for measuring terrestrial subsidies to aquatic food webs using stable isotopes of hydrogen. The potential loss of terrestrial subsidies due to mining might be as great as the loss of marine derived nutrients. It would be informative to discuss the relative importance of marine derived, autochthonous and allochthonous nutrients. Such information might influence "best mining practices" that can maintain allochthonous inputs.

6. Figure 3-2E indicates that wildlife quality, quantity or genetic diversity, as well as wildlife predation, are important to Alaska Native Cultures. Tribal elders are said to have concern for "potential direct effect on other subsistent resources" (which includes wildlife and vegetation). In addition, Appendix D comments on concerns regarding wildlife such as caribou and vegetation such as berry gathering that are not directly linked to the fisheries. An assessment of the direct impact of potential mining as well as the ongoing exploration on wildlife and vegetation would address the concerns mentioned above.

7. Comments in Volume 1 (page 5-76, first lines) indicate that information on wildlife and potential direct impacts are being collected but are not included. Including measures of direct wildlife impact, in addition to indirect impact as a result of changes in fisheries, would greatly improve the assessment. There are many ways to estimate the impact of habitat loss on wildlife (Morrison et al. 1998). A better understanding of impacts on wildlife would presumably provide a better technical basis for designing a reclamation plan.

8. The assessment (page 5-77, last sentence) states: "Although this assessment is focused on salmon, the non-salmon-related impacts on native cultures from routine mine operation are likely to be more significant…" If this is in fact the case, what better reason could there be for increasing the scope to include wildlife, vegetation, community and ecosystem structure and function? Methods and examples for mining for such an assessment, including functions, are available from the Northwest Habitat Institute (nwhi.org) in Corvallis. Discussions with Tom O'Neil, Executive Director, indicate that available data from the Alaska GAP and Alaska Heritage Program could likely be used to make such assessments.

9. The Risk Assessment focus on "indirect effects on wildlife" (page 5-1, para 2) is consistent with some of the several goal statements that lean toward fish influence on wildlife. I have difficulty reconciling this emphasis because further on in the text (page 5-75, para 1, last line) it is stated that the "indirect effects cannot be quantified". If the indirect effects cannot be quantified, one should think it is even more important to get a handle on the direct effects, which can be assessed by any one of several wildlife methodologies (Morrison et al. 1998).

10. The assessment indicates the exceptional quality of the fish populations and their importance to the region's wildlife is due to five key characteristics. The fourth characteristic is "the increased ecosystem productivity associated with anadromous salmon runs" (page 2-20, Section 2.3). Similar statements are made by Woolington (2009). How is this increase measured, and what is the baseline for the increase? I am sure he and others are trying to convey the concept that the energy and marine derived nutrients provided by salmonids increase primary and secondary production in the terrestrial ecosystems in the Bristol Bay watersheds. I am not sure that such a statement considers the loss of energy and marine derived nutrients as a result of commercial fishing. Is it possible that commercial harvest may decrease ecosystem productivity compared to productivity prior to pre-European (e.g., 200 hundred years ago) harvests?

Perhaps it would be more accurate to delete the word "increase". On the surface this might seem like a small edit but this edit is one of many edits needed to address not only the existing conditions in the watersheds but also the existing conditions relative to "pre-European conditions". My understanding of a Cumulative Impact Analysis is that it includes past assessments of ecosystem resources and functions as well as current and future conditions (see discussion of Charge Question 11 on Cumulative Impacts).

11. Pauly et al. (2000) and Libralato et al. (2008) address the energy impacts of fisheries. I would be interested to know if the impact of fisheries on marine derived nutrients and energy available to the wildlife and terrestrial ecosystems in the Bristol Bay watersheds could be compared to the potential impact of the proposed mining on marine derived nutrients and energy available to the watersheds. Is the potential impact of the mine small in relation to the impact of commercial fishing or very large compared to commercial fishing? Such information would be informative for determining acceptability of risks. It is possible that such a comparison could stimulate discussion of the possibility of compensatory mitigation for losses due to mining.

12. The assessment could be greatly improved if more of the linkages and pathways illustrated in the various Conceptual Models were addressed and if impacts on ecological parameters such as community succession (down gradient, in the lake and on tailings and waste rock) and aquatic and upland structure and function were addressed. For example, Site Reclamation is illustrated and highlighted as orange boxes in three places on Figure 3-2C. I'm not sure what the orange highlight signifies, but Cumulative Loss is also highlighted in orange. Information on possible wildlife limiting factors (e.g., calving and nesting habitat) and plant communities in the watershed could improve the quality of Site Reclamation.

13. The discussion of wildlife species in Volume 2, Appendix C is very good, but little of the insight provided in these descriptions of hunted or trapped species is reflected in the assessment of impact of potential mining practices on wildlife. I cannot help but wonder (i.e., mixed message) why Appendix C is so thick and so little of the good information in Appendix C is reflected in the assessment document. For example, the impact of noise and human presence related to mining and roads is addressed on page 54 (Appendix C). Such an impact on certain sensitive species could be equal to or greater than the loss of wildlife habitat in the mine footprint. Woolington (2009) indicates that the Red Dog Mine in Alaska has implemented certain measures that have reduced the impact of the haul road on wildlife. It would be good to know what these measures are and if such measures would be equally effective for a road relatively close to Anchorage.

Question 11. Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?

David A. Atkins, M.S.

Cumulative risks result from the potential development of at least five additional prospects: Humble, Big Chunk, Groundhog, Sill and 38 Zone. The loss of stream lengths and wetland areas that potentially support salmon and resident fish from the development of these projects are quantified under a 'no-failure' scenario. As with the Pebble scenario, it would be helpful to put this loss of resource in perspective in terms of the fish resource as a whole. It would also be helpful to describe any mitigation measures that are feasible to offset the impact of loss of streams and wetlands. It would also be helpful to better understand the role these developments could have in further fragmenting salmon populations.

As with the Pebble scenario, a failure of any one of the TSFs would result in a long-term, catastrophic impact. Therefore, it is imperative that if any of these projects are built, they are also subjected to the strictest standards and most innovative approaches to tailings and waste rock management.

It would be helpful to describe in more detail or at least mention the following potential subsidiary impacts from this development:

- The extensive road network required to support mines in the area and the attendant development associated with this network.
- The camps associated with the project, in-migration of workers to the project areas, and the demand for resources to be imported from outside the area.

Steve Buckley, M.S., CPG

The assessment appropriately describes the potential for cumulative risks from the development of multiple mines in the area.

Courtney Carothers, Ph.D.

In general, the report suggests that effects from multiple mines would increase the prevalence and cumulative impacts of the risks described for the one-mine scenario. Again for the cultural assessment, the conclusion is made that effects on humans would be primarily "direct and indirect loss of food sources" (7-15). As the number of large-scale mines increase in this region, the entire subsistence way of life could come under threat. This would be a much larger impact than lost food sources.

Dennis D. Dauble, Ph.D.

Individual risk is described in varying levels of detail with overall risk or effects considered to be largely additive. The relative magnitude of the effects of mining each ore deposit is difficult to discern. It's possible that one of the smaller ore sites could be developed within an acceptable risk scenario, but it's difficult to determine given that the assessment is largely built on potential impacts of the Pebble Mine. To put things in perspective (individually and cumulatively), a discussion of habitat lost given each of the individual mine footprints, during normal operations (includes water treatment and withdrawal), and as a result of pollutant exposure. Also, Section

7.4.1 of the main document provides estimates of stream miles affected due to blockage and elimination, but nothing quantitative for other direct and indirect impacts of mine operation. The cumulative risk discussion in Chapter 7 could be expanded to link up with the conceptual model described in Chapter 3.

Gordon H. Reeves, Ph.D.

I found this chapter well done, even though the analysis was less extensive that what was done for the Pebble Mine. It is clear that multiple populations would be put at varying degrees of risk simultaneously if mine development occurs as is portrayed in this report. This certainly could compromise the "portfolio effect" (Schindler et al. 2010 Nature 465|3 June 2010|doi:10.1038/nature09060), which has maintained the long-term productivity of sockeye salmon in Bristol Bay.

Charles Wesley Slaughter, Ph.D.

Yes – but a qualified "yes". The Assessment appropriately outlines the probability of additional resource extraction projects beyond Pebble itself, and recognizes that additional resource opportunities (beyond the claims depicted in Figure 4-6), currently unknown or unverified, could become viable or desirable to some interests in the future. Section 7.4 summarizes many of the risks. However, the brief coverage (16 pages) accorded the entire subject of "cumulative risks" is **not** consonant with the very long-term, spatially dispersed (and presumably linked by transportation and communication corridors) impacts and risks of multiple mines (and associated infrastructure) in many different sectors of the Bristol Bay watershed.

John D. Stednick, Ph.D.

Cumulative effects are defined as the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-federal) or person undertakes such other actions (40 CFR ~ 1508.7). This chapter identified potential mine sites and stream lengths that each mine footprint would cover and summed them, rather than assess the cumulative effects of the aggregate of past, present, and reasonable foreseeable future actions. (The assessment does not identify any past activities, which is doubtful even in SW Alaska and does not define a baseline condition for which to compare many individual or cumulative effects). There are many factors that could be included in the cumulative effects analysis, from multiple mines. Human footprint of physical infrastructure: work camps, schools, community services, recreation, increased road access for visitors, sewage treatment facilities, urbanization/industrialization effects on habitats and environment, transportation corridor, pipeline corridor, water resources usage, and regional and global climate change.

Roy A. Stein, Ph.D.

Cumulative Risks from Multiple Mines. Clearly, as amply demonstrated in the Environmental Risk Assessment, cumulative risks would be greater than those from just the Pebble Mine, even though these risks are difficult to quantify. Important points made in this section deal with the economics of additional mines coming to the Bristol Bay Watershed. After the first mine, new mines become more profitable simply because some of the infrastructure (roads, power, fuel pipelines, etc.) has already been provided, thus reducing cost outlays for the establishment of new mines. To me, this seems as quite an insidious process for once the door is swung open for the first mine, then many more will follow owing to infrastructure considerations; with these additional mines come far greater cumulative environmental risks. Quantifying these risks would help the reader and the public understand what the ramifications of allowing one mine to begin operations might be.

William A. Stubblefield, Ph.D.

The potential for cumulative risks associated with the development of multiple mines in the Bristol Bay watershed is not treated with a great degree of detail. Although each of the potential stressors (e.g., water withdrawal, habitat illumination, road and stream crossings) are acknowledged and addressed, little quantitative consideration is given to the potential effects associated with development of multiple mines. This, however, is probably appropriate given the hypothetical nature of the single mine scenario and the potential for greater impacts associated with the development of multiple lines. Short of concluding that "failures at one mine could be bad and failures at multiple mines could be worse," little else could be concluded. It is noted that the multiple mines scenario leads to multiple tailings impoundments, more roads and culverts, increased discharge potential of contaminated waters and increased habitat loss and reduction of water resources and all of these lead to potentially greater environmental injury as a result of failures.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not appropriately describe the potential for cumulative risks from multiple mines. In fact, the assessment does not identify the risks, only the likelihood of occurrence and the consequences. See discussion under Question 4 above about estimating and expressing the magnitude of risks and what is required to appropriately describe the potential for cumulative risks from multiple mines.

The cumulative assessment is very conceptual at best as there are no specific proposals from any of the other potential resource areas. Cumulative impacts can only be evaluated once further details about other potential mines and their plans are available. At this time this section can at best be seen as speculation.

It is impossible to improve this part of the assessment with the information on mine development currently available, it can only be done when further information is published by the various mining companies.

Phyllis K. Weber Scannell, Ph.D.

There are two issues that should be considered: cumulative effects from a single mine and cumulative effects from multiple mines. Cumulative effects from a single mine might include aquatic habitat degradation from non-point sources, including run-off from exposed mineralized rock, seepage from the tailings impoundment, contaminated dust, noise and other forms of disturbance.

Cumulative effects from multiple mines are difficult to predict because there are too many unknowns. It is frequently to the advantage of a mineral development company to take advantage of existing infrastructure, without building new camps, new mills, etc. It is also possible to use an old mine pit for tailings disposal from a new site; however, none of these features can be determined until there is sufficient exploration to determine if mineral development is feasible, to characterize the deposit and to develop a detailed mine plan. To date, there is not sufficient information to predict cumulative effects from multiple mines.

Paul Whitney, Ph.D.

EPA's guidance for reviewing cumulative impact analyses (EPA 1999 – most recent guidance on EPA's website) asks that past, present and reasonably foreseeable actions be considered. The assessment's coverage of cumulative risks from multiple mines certainly addresses "reasonably foreseeable" mines (with the possible exception of heap leach processing for gold, see response to Charge Question 2). Not addressed in the analysis are past impacts and how these impacts might be additive to foreseeable impacts. As commented above, commercial fisheries remove a lot (up to 70% – over 10 million fish) of the salmon from the drainages associated with the mine. The continual annual loss of energy and nutrients that might otherwise return to the ecosystems should be considered a past impact as part of the cumulative impact analysis. I have prepared/managed cumulative impact analyses of fish and wildlife for relatively small (e.g., a 200 acre aggregate mine) and a relatively large 7,100 acre coal mine in Washington. A cumulative impact analysis of past, present and future fish and wildlife losses for a coal mine expansion in a large watershed indicated cumulative impacts of the expansion were less than one percent of past mining, agriculture and forest activities in the watershed. In addition, the cumulative loss could be fully mitigated by compensatory restoration. I would be interested to know what estimated fish and wildlife loss due to the example copper mine is in comparison to the loss related to the commercial fishery. In addition, I would be interested to know if potential fish and wildlife losses due to mining could be fully mitigated. If the watershed is pristine or nearly pristine, the opportunity for compensatory mitigation may be low. There is not much degraded habitat that could be improved by a mitigation plan. If such a cumulative impact analysis were conducted, it may stimulate conversation about reducing commercial fishing to compensate for impact losses due to mining.

Question 12. Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?

David A. Atkins, M.S.

The Assessment describes what is considered to be conventional mining practice. For mines located in the Bristol Bay watershed, conventional practice is not sufficient. Therefore, it is important to consider mitigation on numerous fronts when determining the viability of the project. A section on innovative and state-of-the-art approaches for both mitigation and construction of mine facilities would be helpful to better understand if risks can be minimized or eliminated given sufficient funds.

Under the no-failure scenario, the footprint of the mine (open pit, block-cave subsidence zone, waste rock and tailings areas) will necessarily destroy habitat. There may be ways to create equivalent habitat to compensate for lost habitat in areas within the watershed that are currently not productive for fish. This form of mitigation may work for resident fish. It is unclear if it would work for anadromous fish that return to very specific locations to spawn. So it seems that at least some genetic diversity would be lost for salmon due to habitat lost in the project area even if sections of habitat were enhanced or created that replaced habitat destroyed.

It is also becoming common practice to offset impacts from project development with preservation of equivalent habitat areas that are also at risk from development (http://bbop.forest-trends.org/). It is unclear if this is a feasible consideration for this project as this could involve allowing one development (e.g., Pebble), while potentially taking away the development rights of others (presumably for proper compensation).

Higher standards for mine facility construction could lessen the possibility of failures, but would also come at substantial cost to the project. Innovative mine waste management methods that could be considered include:

- 'Paste rock' tailings management that mixes acid generating waste rock with tailings[3]. This approach has two benefits:
    - It isolates acid generating waste rock within saturated tailings and thus minimizes or eliminates acid generation potential. The current approach calls for running PAG material through the mill at the end of the mine life and placing the resulting project in the impoundment. This approach requires collection and treatment of ARD from the PAG rock during operation.
    - Adding waste rock to tailings provides geotechnical stability to the tailings facility and could greatly reduce the impact of any breach of the dam.
    - It lessens the storage area necessary for waste rock (waste rock facilities have an inherently high porosity, but in this case part of this porosity would be filled with

[3] Wilson, W., 2008. Why Are We Still Struggling Acid Rock Drainage? Geotechnical News, June 2008. pp. 51 - 56. : http://www.infomine.com/publications/docs/Wilson2008.pdf

    tailings), but would increase the tailings storage area.
  - It would lessen and potentially eliminate the need for perpetual geotechnical maintenance and water treatment.
  - The disposal method is currently under development and has not been applied at an operating mine, so application is likely not
- Pit backfilling with non-acid-generating waste rock to the original land contour, rather than merely in the last phase of mining:
  - Allows the original land contour to be reconstructed.
  - Lessens the area necessary for waste rock disposal.
  - Eliminates the possibility of creating a pit lake that could serve as an 'attractive nuisance' that could be used by waterfowl.
  - Potential effects on local and regional hydrology, including groundwater quality and quantity impacts would need to be assessed.
  - This could require double-handling of rock, which would increase cost.

Steve Buckley, M.S., CPG

There are many reasonable mitigation measures that could reduce the risks and impacts beyond those described in the assessment. Many of these are contained in the Appendices and referenced therein but not discussed in detail or described in the assessment. It is beyond the time constraints provided in this review to develop an exhaustive research list of these potential mitigation measures, however they could include measures designed to reduce the mine footprint and limit the number of potentially affected watersheds, reduce, isolate or eliminate the amount of potentially acid generating waste, provide secondary containment measures for all pipeline corridors and the use of natural streambed arch culverts and bridges at fish bearing stream crossings.

Courtney Carothers, Ph.D.

While I do not have knowledge of mitigation measures, a more thorough discussion of mitigation measures could be included. Even if mitigation measures are largely deemed to be ineffective, in this case, they should be presented and evaluated as such.

Dennis D. Dauble, Ph.D.

Potential mitigation measures are well described in Appendix. I have no suggestions for additional measures. Implementation of mitigation measures is entirely dependent on the regulatory framework for operations and the oversight and monitoring practices that would be mandated as a condition of the mining activity. Thus, some discussion of how/which mitigation practices would be most applicable in the Bristol Bay watershed (and limitations thereof), given constraints and characteristics of local hydrology and geology, is warranted.

Gordon H. Reeves, Ph.D.

I identified one potential mitigation for culverts, use of open arch types that are at least one bankfull width in size. As described in my answer to Question 7, this could reduce many of the potential impacts raised by the authors.

Charles Wesley Slaughter, Ph.D.

If it is assumed that the PLP project, or some similar development, were to go forward, I cannot suggest mitigation measures beyond those discussed above. Since a major concern for salmonids – perhaps THE major concern – is with consequences of the transportation corridor, simply having the mine without the roads/pipelines would alleviate much potential risk. However, there is presumably no practical, economically feasible way to not have the transportation corridor; air transport of all materials to and from the site might technically be possible, but would not be economically feasible.

John D. Stednick, Ph.D.

The purpose of this assessment is not to identify mitigation measures. This suggests that things can be fixed by mitigation. Risks were identified for a variety of situations, and the preventative measures would better address the mining impacts. Mitigation measures are also a mining cost that needs to be determined by the mining company.

Roy A. Stein, Ph.D.

Mitigation: Complete Tailings Storage Facility (TSF) Failure. In some ways, some of the failures reviewed herein are not really subject to mitigation. For example, if a Tailings Storage Facility (TSF) completely fails, options for mitigation become limited very quickly. With a complete failure, it is "game over", with toxic sediments flowing into the Nushagak River all the way to Bristol Bay, thereby destroying the entirety of salmonid spawning habitat in this river by redirecting the channel and inundating the gravel/cobble steam bed with sediment (meters in depth). Mitigation under these circumstances is impossible, in my view.

Dry Stacking Mine Tailings: Appendix I, page 9. Given the horrific impact of a TSF dam failure, should mine operators consider a relatively new technique incorporating "paste tailings technology"? Here, tailings are thickened by water removal (down to 20% water) and filtering; tailings are then dry stacked onto a lined disposal site. These stacks "have a lower potential for structural failure and environmental impacts (Martin et al. 2002).

Mitigation: Partial TSF Failure. If a TSF partially fails or is discovered beginning to fail, then I believe mine operators have a chance to save the dam and thereby protect the river, but only if 1) the appropriate Standard Operating Procedures (SOP) for an emergency response are in place, 2) the necessary equipment (my presumption here is that heavy, earth-moving equipment would be required), materials, and supplies are onsite near the facility, and 3) trained personnel (meaning that they have practiced these repair SOPs in the preparation for such an event) are available for immediate action. One might argue that these procedures are more proactive than mitigating and I would agree, reflecting the near impossibility of invoking any mitigation measures associated with TSF failure.

Dredging: Post TSF Failure. In the text (pages 6-1 to 6-2), a reference is made to dredging materials out of the river post spill. I can't imagine this would mitigate any losses of spawning substrate for salmon. Indeed, because only 5% fines in gravel substrates compromise salmon reproductive success (and perhaps even selection of these areas for spawning in the first place), removal of meters of sediment with a dredge doesn't seem to be a solution. Whereas dredging might, in a best-case scenario, reduce the time to recovery of the substrate, I don't believe it will hasten recovery significantly. Dredging also serves to bring toxic sediments up into the water column perhaps compromising all organisms in the system. By not dredging, we allow the natural system to recover, which, in my view, would be preferable to any sort of "dredging mitigation".

Mitigation: Pipeline Failure. With automatic shut-off valves stationed along all four pipelines, we would expect to know precisely just how much effluent will be spilled during any single event. With this information in hand, mine operators can easily anticipate spill size, toxicant characteristics and thereby judge what equipment, materials, and supplies would be necessary for mitigating any spill. As with the TSF failure, mine operators should have in place: 1) the appropriate Standard Operating Procedures (SOP) for an emergency response, 2) the necessary equipment, materials, and supplies onsite near the pipeline (given the length of the road, these items should be cached at several locations along the road, such that response time is minimized), and 3) trained personnel (meaning that they have practiced these mitigation SOPs in the preparation for such an event) are available for immediate action.

Mitigation: Failure of Water and Leachate Collection. This failure differs from TSF and pipeline failure, where failures are more akin to catastrophic, for here failure is somewhat more gradual in coming (my guess is). Proactive vigilance is the watch phrase here where continual, careful monitoring will indicate when failure begins. Because the "spill potential" is relatively small (certainly compared to a TSF failure), less urgency is required on the part of mine operators. However, as pointed out previously, just because the potential is small, over time the impacts could be great. Hence, the mitigation undertaken with water and leachate collections would require (one would hope) just the tweaking of the collection system in place to eliminate leakage through time. Again, personnel trained in how to respond to these gradual increases in water and leachate leaks are required to stay ahead of this issue, thus preventing any toxic materials from flowing downstream into the Nushagak and Kvichak rivers.

William A. Stubblefield, Ph.D.

I'm sure there are number of technological/engineering measures that could be implemented to reduce the potential for environmental injury associated with development of mining in the Bristol Bay watershed. The development of this *a priori* risk assessment provides useful information in identifying were potential risks may exist and should provide mine development professionals with the degree of guidance about the types of risks and potential consequences of mine activity failures. Perhaps by recognizing the magnitude of adverse consequences associated with potential failures, steps can be taken to implement safety measures early in the planning process that would render mine development more acceptable. Again, because of the lack of detail associated with the hypothetical mine scenario, it is impossible to estimate the likelihood of success of any mine control activities.

Dirk van Zyl, Ph.D., P.E.

Yes, there are reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described and incorporated by the EPA in the assessment. There is a host of measures that are not addressed in the assessment, a list of these are identified below under the headings of regulatory and engineering. This list is by no means exhaustive.

While the EPA Assessment presents a series of potential mitigation measures, the majority was rejected.

Multi-stakeholder engagement processes can be used to further expand on these mitigation measures. It is recommended that EPA recognizes these and potentially other measures that may be proposed in the public comments and make a serious effort in including the potential effects of these on failure likelihoods, consequences and risk magnitudes. It is an important aspect of improving on the range of potential outcomes.

Regulatory. The EPA Assessment neglects the typical outcomes resulting from the permitting and regulatory processes for new mines where permit stipulations may require specific actions resulting from discussions, public comments and regulatory frameworks. The following is a partial list of these:

- Section 404 of the CWA (See discussion under Question 3 above).
- Permitting stipulations and requirements for monitoring. Using permit stipulations for monitoring can reduce a large number of the consequences identified in the report. For example, the consequences associated with blocked culverts, etc. can be significantly reduced by permit monitoring requirements and subsequent enforcement.
- Financial assurance will be required for mine closure. Financial assurance can be a very beneficial tool during operations, premature closures, mine closure, as well as post-closure monitoring and maintenance. Experience gained during operations can help develop the closure and post-closure financial assurance requirements.

Engineering. A number of engineering options are mentioned in the report but discounted in many cases. Many of these engineering mitigations are currently used in the industry. The following may repeat a number of those mentioned in the report:

- Redundancy, e.g. additional embankments can be constructed downstream of the TSF to contain tailings and supernatant that may be transported as a result of TMF failure. While this may result in a larger surface impact it will protect downstream waters in the case of a failure resulting in tailings discharge.
- Tailings management options other than slurry deposition.
- Waste rock management options to reduce releases during operations, e.g. addition of lime to the PAG rock.
- High standards implemented for road design, construction, monitoring and maintenance.
- Double containment of all pipes containing concentrate and other materials. This is already required under the International Cyanide Code for all pipelines containing cyanide solutions.

The likelihood of success of these proposed and other potential mitigation measures can be evaluated by considering their impacts on the overall project. A series of alternatives will have to be developed instead of using only the hypothetical scenario.

Phyllis K. Weber Scannell, Ph.D.

There are many avoidance or mitigation measures that would be implemented to reduce or minimize mining risks. I have described some possible approaches when answering the previous questions. To summarize:

The two most important questions for reducing or minimizing mining risks are:
- Can a mine in this area be designed for closure?
- Is it acceptable to develop and operate a mine that will require essentially perpetual treatment?

Specific Measures that can be taken to minimize risk include:

Limiting metals contamination and acid drainage:
- Design the mine pit to limit oxidation on pit walls. Where feasible, conduct concurrent reclamation.
- Plans for classification and storage of waste rock, lower grade ore, overburden and high grade ore.
- Development and maintenance of tailings storage facilities with fail-safe provisions. An emergency discharge of untreated waters from a tailings storage facility could be made to a collection pond for later treatment or the tailings pond could be engineered to accommodate a higher flood event so the likelihood of overtopping is minimized.
- Development and concurrent reclamation of disturbed areas, including stripped areas and mine pits.
- Collection and treatment of point and non-point source water,
- Quantity and timing of discharges of treated water; monitoring of ground water, seepage water and surface water.
- Design system for collection and bypass of clean water and collection and diversion of contaminated water to a water treatment system.
- Truck wheel washing.

Protection of Fish Habitat
- Review and permit all instream activities in waters important to the spawning, rearing or migration of anadromous fish.
- Design and implement a biomonitoring program.
- Review and permit every road crossing of fish bearing waters.

Possible Measures to Limit Effects to Wildlife:
- At the planning stages, design aspects of the project to create or enhance wetland and aquatic habitats for fish, bird and wildlife species.
- Limit truck traffic on the haul road during migrations.
- Incinerate all kitchen waste.
- Educate workers on bear (or other wildlife) safety.
- Limit air traffic and noise during critical times of the year.

Paul Whitney, Ph.D.

The key word here is "reasonable". What is reasonable to a person not involved in mining on a day-to-day basis will likely not be reasonable to a mining company executive or mining engineer. The likelihood that "reasonable" means different things to different people is exacerbated by the mixed messages regarding "best" mining practices (e.g., page ES-10, five lines from the bottom) versus "not necessarily best" mining practices (e.g., page 4-17, four lines from the top). As mentioned above, both of these statements can't be accurate. For purposes of this discussion, I am assuming that there are many more mining practices that could be proposed to address many of the uncertainties mentioned in the assessment. First of all, most of the mitigation measures mentioned in the assessment provide one line of protection and I suspect there are many types of redundant mitigation that could be implemented, such as: double-walled pipes in all sections that cross floodplains (above and below grade); poly liner/vegetated caps to soak up and capture run off water before it contacts waste rock; redundant clay, glacial till (waste360.com/mag/waste_landfills_glacial_till) and poly liners; and secondary liquid collection systems. I appreciate the assessment's discussion of the potential difficulties of using poly liners, but the discussion might benefit from a review of Koerner et al. (2005) that provides another perspective on the life of HDPE liners. The relationship of liner life to temperature is presented in their Table 2 and a summary in the text indicates that covered liners have a "halflife of 446 years at 20 degrees Centigrade". This is a lot different from the 20 to 30 year estimate of service life cited on page 4-11, last para. Appendix I does cite a 2011 version of the Koerner et al. (2005), but the paper appears to misquote it (page 9, last para, last full sentence). The Koerner et al. (2005) paper estimates a "<u>halflife</u> of 446 years" not a "<u>lifetime</u>" of 446 years as cited in Appendix I. Perhaps Koerner up dated his 2005 estimate in the 2011 version.

I assume a mining engineer (if asked) could design a series of smaller impoundments or innovative lined impoundments that could avoid a lot of the problems cited in the assessment. The trade-off might be increased loss of natural resources due to a larger footprint and increased construction cost but the reduced likelihood of risk and a catastrophic failure might be greatly lowered. I would be interested to know what THE BEST mining practices are. If the mitigation measures mentioned in Appendix I are, in fact, the best, it should be so stated and taken into consideration in the assessment. For example, page 4-21 of the assessment indicates the TSF would be unlined and not have an impermeable barrier between the tailings and groundwater. Appendix I, page 9 indicates TSFs can be lined if problems are expected. There is a lot of good information in the Koerner et al. (2005) paper and Appendix I. It seems that the types of mitigation measures in Appendix I could be better captured in the main report.

Compensatory mitigation and reclamation are briefly mentioned in the assessment. A more detailed discussion of the opportunities and feasibility of reclamation and compensatory mitigation might reduce the likelihood of potential impacts of the example mine plan (see response to Question 3).

Question 13. Does the assessment identify and evaluate the uncertainties associated with the identified risks?

David A. Atkins, M.S.

As stated in the report, the 'range of failures is wide, and the probability of occurrence of any of them cannot be estimated from available data'. Uncertainty is adequately explained through the report. However, the concept of uncertainty is difficult for people to grasp, so the general understanding of the report among many seems to be that the impact of the project would be 'devastating' to the fishery as a certainty, when in fact we do not know this.

Steve Buckley, M.S., CPG

The assessment identifies some of the uncertainties associated with the identified risks but does not evaluate these in great detail.

Courtney Carothers, Ph.D.

The report includes specific sub-sections to discuss uncertainties for the risks associated with habitat modification (Section 5.2.4), pollutants (5.3.4), and water collection and treatment failure (6.3.4). Uncertainties related to abundance and distribution of fish in watershed draining the mine site, road and stream crossings, salmon-mediated effects on wildlife, salmon-mediated effects on human welfare and Alaska Native cultures, tailings dam failure, pipeline failure, road and culver failures are not discussed in separate sections; however, several uncertainties related to these risks are noted throughout the report, and in summary sections (Sections 8.5 and 8.6).

The "sensitivity relative to overall results" of the key assumptions and uncertainties presented in Table 4.8 in Appendix E (pp 193-195) would be a helpful model to employ in the main report. For non-experts in the technical dimensions of mine construction and operation, uncertainty rankings would be useful. For example, "We are "highly uncertain" about the accuracy of these predictions given this unknown factor," or "We expect this uncertainty has a negligible effect on the model we employ to calculate this risk."

Dennis D. Dauble, Ph.D.

The most likely scenarios and probabilities of failure are described. For the most part, estimated risks are conservative, i.e., effects are stated as "likely" if no further information is available.

Gordon H. Reeves, Ph.D.

Uncertainties and limitations are explicitly identified and acknowledged for topics that I am familiar with (fish and aquatic ecology and fish habitat) throughout the report. These are summarized succinctly and clearly and the consequences to the findings articulated.

Charles Wesley Slaughter, Ph.D.

Yes, the authors fairly attempt (pp. ES24-26, and in each chapter) to note the various uncertainties and assumptions incorporated into Assessment. Sections 8.5 and 8.6 briefly summarize those uncertainties. A question remains concerning the "uncertainties" associated with their assigning probabilities to various failure scenarios; I remain unconvinced that those probabilities have real meaning or significance for decision-making (see response to Question 5, above).

John D. Stednick, Ph.D.

The uncertainties are presented adequately.

Roy A. Stein, Ph.D.

Uncertainties. I think that the ERA did a nice job of identifying uncertainties surrounding this presentation. Even so, I found this section more than disconcerting. Certainly, ERA authors have worked hard to present an accurate portrayal of the impact of a large-scale open pit mine in the watershed of Bristol Bay. Even so, upon review of the list of uncertainties with regard to this effort (pages 8-10 to 8-13), I conclude that we know little of what the impact of this mine will be in any quantitative sense. Clearly, from the ERA, we do know qualitatively what is likely to occur when a mine of this size and type will be put into operation in this environment.

However, from the list of uncertainties, we are operating at the outside edge (and beyond in many cases) of the semi-predictive models used in anticipating the impacts of the mine footprint, the routine operations of the mine, and the impacts of failures of TSF, pipelines, and water/leachate collections on extant salmon populations. And our knowledge of the baseline populations of the seven species of salmonids is no better, for we do not know the size, diversity, distribution, or vital rates (i.e., recruitment, growth, and survival across life stage) of these fishes.

Couple these two sets of uncertainty and the prognosis outlined in the report is suspect, at the very least, and somewhat anticipatory at best (I cannot bring myself to use the word "predictive".). I fully realize that these are the cards the authors were dealt (I do applaud the authors for making the best of an information-poor environment), but it seems to me that we are on tenuous ground when we attempt to predict the impact of the Pebble Mine on salmon, associated wildlife, and Native Alaskan cultures in the Bristol Bay Watershed.

William A. Stubblefield, Ph.D.

The risk assessment attempts to identify and evaluate the uncertainties associated with each of the recognized potential risks. The authors have, for the most part, successfully identified a number of uncertainties that may affect the accuracy and conclusions of the risk assessment. Clearly this information should provide a basis for prospective mine planners and regulatory authorities to focus their efforts to minimize potential environmental risks. In some cases the uncertainties identified are probably best addressed through the development of additional data and this should guide future research efforts undertaken prior to mine development and operation.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment does not identify the risks, only the likelihood of occurrence and the consequences. See discussion under Question 4 above about risk. Uncertainties are identified and evaluated for the likelihoods of occurrence and in some cases for the consequences. However, because the magnitudes of the risks are not expressed their uncertainties are also not explicitly expressed.

The report identifies uncertainties in a number of sections, including in Chapter 8. In many cases these uncertainties are expressed in qualitative terms and are not quantified. The biggest uncertainty/variability in the evaluation of a hypothetical project is associated with the potential range of design features, waste management options and operational details that could be included. This was completely overlooked in the analysis by assuming a specific design for the hypothetical mine. The failure likelihoods and consequences on salmonid fish are very dependent on the assumptions for the hypothetical mine. These uncertainties are neither clearly identified nor included in the evaluations. This is a major shortcoming of the present analysis.

Phyllis K. Weber Scannell, Ph.D.

The important features of the Environmental Assessment are to describe the fish, wildlife and human use of the subject area and to define possible risks from development of a large porphyry copper mine. There are many uncertainties associated with the identified risks and most were identified in the document. The document could be strengthened by putting a greater emphasis on sources of contamination (such as mine seepage, poorly designed collection systems, exposed pit walls, etc.) in relation to the permeability of the soils.

The 5th bullet on page 8-11 outlines important uncertainties for protecting fish species. These uncertainties include life-stage-specific sensitivities to temperature, habitat structure, prey availability and sublethal toxicities. These factors must be considered should a mineral development project go forward.

The 6th bullet on this page discusses the preliminary nature of leaching test data. These tests must be sufficiently comprehensive to predict both short term and long term water quality from all sources, including PAG and NAG waste rock, pit walls and pyritic tailings.

Paul Whitney, Ph.D.

In most cases, the discussion of uncertainties in the assessment is appropriate. It seems that one could use these discussions as a scope for additional work needed prior to an assessment that would properly assess risk of the proposed mine. As the uncertainty discussions appear in the assessment, this reader wonders what to make of it. There is a lot of uncertainty in this world that we find acceptable; the ultimate goal seems to determine if the cumulative uncertainty is acceptable or not. Such an evaluation remains to be made and I'm not sure how it could be made based on the level of information presented in the assessment and the current state of the uncertainty discussions.

The Section 8.5 and 8.6 summaries of uncertainty could be improved if some sort of realistic and useful conclusion(s) could be presented. The 8.6 summary seems to "pile on" uncertainties, rather than summarize the uncertainties in the assessment. While piling on is informative, it is not the sort of summary I was looking for. Conclusions in the 8.5 summary of conclusions remind us that the effects of mining on fish populations could not be quantified and, as a substitute, the effects of habitat were used as a surrogate. So we are left with an estimate of 87.5 to 141.4 km of streams that would be removed and this would cause an adverse effect. Based on this very general risk conclusion, we learn that "In summary, it is unlikely that there would be significant loss of salmon subsistent resources related to the mine footprint" (page 5-77, last paragraph). First, it's not clear how this conclusion was reached and second if such a conclusion was possible for subsistent resources based on the data available, why couldn't such a conclusion be reached for sport and commercial fisheries? Third, does it follow that no significant loss to salmon subsistent resources would result in no significant loss to wildlife that utilize this resource? If so, such an indirect analysis is not informative regarding an environmental assessment for the example mine. Alternatively, a direct assessment of the loss of habitat using habitat-based population models for both fish and wildlife would be much more informative.

Holling (1978), in his Adaptive Environmental Assessment and Management book, discusses political uncertainty and how adaptive management might be able to address the issue. Considering that the mine being proposed is a multi-century system, it's poignant to realize that Alaska was owned by Russia about 50 years ago and Oregon was owned by the Spanish about 200 years ago.

Adaptive management is a tool designed to deal with uncertainties in risk evaluations (Ruhl and Fischmann 2010). If implemented properly, with testable hypotheses of risk, adaptive management may be something to consider for the proposed mine. My experience with adaptive management is that adequate funds are seldom allocated to learn by doing, to test hypotheses and to implement new management if hypotheses are not met. Formalizing financial instruments to ensure that funds are available is equally difficult to negotiate. Nonetheless, I agree with Ruhl and Fischmann that the theory of adaptive management is sound and may be the only way to deal with uncertainties such as climate change. Considering the number of uncertainties identified in the assessment, for the scope of work to clearly state hypotheses, to fund studies to test the hypotheses and to fund alternative management if hypotheses are not met are cumulatively daunting. I am not aware of any alternative to adaptive management other than contingency planning, which often lacks the "learn by doing" feature of adaptive management.

So many of the uncertainty evaluations make statements about certain parameters that "could not be predicted" (Page ES-20, para 4); "could not be quantified" (e.g., page 6-11, second full para); or are "unpredictable" (page 5-44, para, line 8). These are just a few of many examples. It would be more acceptable, at least to me to state that estimates were not included in the assessment. This type of wording occurs in some parts of the assessment and might be more accurate.

The assessment includes a lot language that seems vague, at least to me. The list is long but includes: highly pure water; other ecological responses; key wildlife, essential wildlife, overall ecosystem functioning; serious population-level consequences; different thermal characteristics; could be locally significant; and very long time. Lackey (2001) acknowledges the need for scientists to communicate with the public using normative science but expresses concerns that normative descriptors such as ecosystem health are subject to wide interpretation. He suggests that the most direct alternative to using normative science is to simply and clearly describe what is being discussed. The assessment would benefit if the normative type words used above (any many more) were quantified with estimates, a range or some type of measureable or testable parameter.

Question 14. Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?

David A. Atkins, M.S.

Long-term risks from the Pebble West open pit have not been characterized. It is difficult to predict the chemistry of the lake that will form in the open pit, but there is some potential that water quality will be poor, which may be exacerbated by pit backfilling with waste rock. The pit lake could impact waterfowl and may have some impact on groundwater if there is outflow when the lake reaches and equilibrium level.

Steve Buckley, M.S., CPG

None.

Courtney Carothers, Ph.D.

All other comments are contained below, in Specific Observations.

Dennis D. Dauble, Ph.D.

Not at this time.

Gordon H. Reeves, Ph.D.

The major issue that was not considered in the assessment was the potential impact of climate change, particularly regarding the form and timing of precipitation. Admittedly, there is uncertainty about the magnitude of changes that will result from climate change, which makes it difficult to consider. However, the potential consequences of climate changes on such topics as tailing site facilities, water availability, and culvert failure seem appropriate. It will also be important to consider potential impacts of climate change so their signal can be distinguished from potential mine impacts during any monitoring that occurs.

Charles Wesley Slaughter, Ph.D.

None.

John D. Stednick, Ph.D.

There are several references to streamflow measurements that would be helpful to better characterize the site. The U.S. Geological Survey has some streamflow gauging stations and precipitation records that would complement the analysis. Annual precipitation values were derived apparently from a computer model used to analyze global climate change at UAF. How do these data compare to field measurements? The prediction of a 10, 50, 100, or larger event using a short-term precipitation record, results in a larger error term on the predicted streamflow. How common is the occurrence of rain on snow (ROS) streamflow events?

Dust production and transport. A variety of mining processes will generate dust. What are the wind patterns, chemical composition and opportunity to land in surface waters or wetland areas? What potential is there for metal or toxin transport? Overburden removal will require explosives that leave nitrate, ammonia, and often sulfur in the air. What about this transport? Or rain out?

Roy A. Stein, Ph.D.

IN PERPETUITY

Sustainable Salmon vs. One-Time Mine. Some irony exists as one considers the trade-off between salmon and this mining operation (and make no mistake, we cannot have both mining and productive salmon stocks in the Bristol Bay Watershed). We are trading sustainable salmon stocks that, with science-driven management, rigorous regulatory oversight, and limited exploitation, should provide salmon literally 1000s of years into the future against the development of a mine that will provide minerals in the relative short term (within 25 to 78 years). As a result of the mining operation, the government (and likely it will be the state or the federal government) will be saddled with a 1000 years (at a minimum, based on the ERA) of monitoring and maintenance of this closed-mine site. Tradeoff indeed.

MINERAL NEEDS

Strategic Needs. I was surprised that no section of the ERA included any justification for why copper, gold, molybdenum, and some additional rare earth elements were needed within the context of our economy. Are other sources available? Are these specific elements in short supply? Are they required for the USA to compete in worldwide markets re cell phones, other electronic devices, or solar panels? For example, rhenium is used in the aviation industry and some web sites suggest it is critical to our defense industry. Some justification would have helped me understand this huge undertaking.

ORGANIZATIONAL ISSUES

Page 5-59. I struggled throughout the document with organizational issues. As I read more and more text, I had the sense that I had read these facts or these perspectives previously. I mention this above but it is here on page 5-59 that the issue is nicely summarized. Note the next to the last paragraph on the page, where it discusses all of the important issues associated with roads and stream crossings. My suggestion would be that these sections (for every topic) be combined such that one section would exist for Roads, one for the Pipelines, etc. In so doing, the reader can capture all of the relevant information about a specific aspect of the mine in a single section of the report. I believe this would improve impact, readability, and shorten the report substantially (and also serve to reduce what seems to be a fair amount of redundancy).

Pages 6-10 to 6-11. These pages reflect another example of redundancy. Text to this point discussed and reviewed just how long we might expect the fine sediments to persist in rivers and streams post tailings dam failure. Yet, here again, on pages 6-10 to 6-11, these numbers are reiterated. Combining these sections would help the reader and reduce redundancy.

Section 6.3, Pages 6-36 to 6-42. Not to beat a dead horse, but in this section, nearly all of the citations to tables and figures are to those tables and figures that are found in sections of the report other than Section 6. This organizational scheme is what makes the report cumbersome to read and follow the logic and the argument.

Literature Cited

Kovach, Ryan P., Anthony J. Gharrett, and David A. Tallmon. 2012. Genetic change for earlier migration timing in a pink salmon population. Proceedings of the Royal Society B published online, July 11, 2012, doi: 10.1098/rspb.2012.1158

William A. Stubblefield, Ph.D.

I have no additional comments add at this time.

Dirk van Zyl, Ph.D., P.E.

The EPA Assessment mentions twice that "interactions with regional stakeholders" and interactions with members of the Intergovernmental Technical Team were used to refine the analysis, etc. (p. ES-2 and p 3-6). A robust stakeholder process includes careful documentation of the stakeholders identified during the project (which may include stakeholder mapping), records of meetings (attendee lists, meeting notes, etc.), resolution of differences, etc. The EPA Assessment does not contain any references to any such materials, which implies to me that the stakeholder process was informal and not robust.

On p. 1-2 of the EPA Assessment the following statement is made: "The third driver for this assessment is multiple requests for the U.S. Environmental Protection Agency (USEPA) to become involved to protect aquatic resources and salmon in the watershed. Nine Bristol Bay Federally Recognized Tribes, the Bristol Bay Native Association, the Bristol Bay Native Corporation, other Tribal organizations, and many groups and individuals have asked USEPA to restrict certain large-scale mining activities in the Bristol Bay watershed using its authorities under the Clean Water Act. These groups are concerned that large-scale mining could adversely affect the region's valuable natural resources, particularly its fisheries".

I am not an expert on policy-making or a lawyer; however I have been involved with regulatory processes, including the development of regulatory guidelines at the state level. Process is an essential component of good policy making. Making a major decision such as restricting large-scale mining activities in an area the size equivalent to West Virginia should be preceded by the development of a process to make such important decisions. Such a process should ideally be established through multi-stakeholder engagement followed by the regular process of Federal Register notices and public comment periods. Using a hypothetical mine based on a published report by a partner of the proponent as a basis for the evaluation and then stating: "The scenario does not represent specific plans of any mining company" (p. 8-10) does not build confidence that the process is robust. It can set the US on a slippery slope in terms of future decision-making about mining and other large resource projects in sensitive areas. It is recommended that the EPA develop a multi-stakeholder process for the evaluation of such difficult regulatory decisions so that it is a diverse group truly representative of those working towards the goals defined by the stakeholders.

Phyllis K. Weber Scannell, Ph.D.

At present, Pebble remains a prospect and there is no plan of operations for the mine. Should the project move forward to development of a mine, it will be necessary to develop an in-depth mining plan of operations. The mining plan should include the following:

- Transportation – of equipment and personnel and for shipping ore. Transportation of ore, including loading facilities, wheel washing and other measures to prevent ore spillage and contamination.

- Siting of mine facilities, including tailings ponds, waste rock storage areas, concentrate storage area, bypass systems for clean water and collection systems for contaminated water.
- Mill operations, including a description of the process for concentrating ore.
- Chemical and fuel storage and Spill Prevention and Contingency Plans.
- Personnel housing, including handling of domestic waste (sewage, garbage).
- Water treatment plant. Processes that will be used, anticipated concentrations of metals and TDS, anticipated discharge volumes and predicted mass loadings.
- Monitoring plans for seepage from tailings ponds, waste rock storage areas, etc. Monitoring likely will include a series of wells and possibly, a pump-back system.
- Predictions for acid rock generation and measures that will be put in place during mineral development to minimize future seepage from the mine site.
- Plans for concurrent reclamation and future closure of the mine.
- Specifications for sufficient bonding to provide site stabilization and water treatment in the event of a premature or temporary shut-down and reclamation at closure.

After the Mine Plan of Operations is developed, an environmental assessment plan should be developed that identifies potential effects to fish and wildlife and their habitats from specific components of the mine (as listed above). In addition, the assessment should include cumulative effects of nearby mines (if appropriate) on fish and wildlife habitats and water quality.

Among the most important issues that must be addressed are transportation, potential for acid mine drainage and metals leachate, control of point and non-point pollution and developing the mine for future closure.

Paul Whitney, Ph.D.

Here are a number of other comments that do not fit neatly under the first 13 Charge Questions.

1. Unquantifiable parameters. There are many parameters that are supposedly unquantifiable. An example "unquantifiable" parameter is the area of riparian floodplain (page ES-14). Another example is the "unquantifiable area of riparian floodplain and wetland habitat that would be lost… (page 8-2, first sentence)." There are many methods to characterize or delineate riparian floodplain and wetland. For example, information in Table 5-23 and associated text on page 5-69 characterize wetland loss within 100 and 200 meters of the road. This is a rather crude method, but it is at least an estimate. Perhaps it would be accurate to say that the area of riparian floodplain and wetland habitat lost was not characterized? Such a statement would be more internally consistent with statements that the natural system is "incompletely characterized" (page ES-25). Better yet, characterize the loss using one of the many existing methods. Section 8.2 is a good start.

2. Ecological resources can be characterized at many levels of organization. Populations are often characterized by birth and death rates. Communities are often characterized by species diversity, succession, and associations of species. Ecosystems are often characterized by structure, function, nutrient cycling and energy flow. From a wildlife perspective, the assessment does a fine job of discussing marine derived nutrients but

concludes that "…the fish mediated risk to wildlife – cannot be quantified given available data…" The assessment could be improved if information regarding community and ecosystem parameters were included. Woolington (2009) comments on the importance of certain seral stages for wildlife. I am confident that an interview with him, reclamation specialists and others at ADF&G could provide a lot of information on community succession, plant diversity and wildlife habitat relationships. This information, in addition to the insight provided in Appendix C, would provide a much better understanding of possible mine impacts and opportunities for compensatory mitigation. It is also possible that traditional knowledge of villagers might provide insight to understanding plant community and ecosystem parameters.

3. Ecosystem Integrity (Section 2.3.5) seems to miss the mark. It mentions the "nearly pristine conditions" with the caveat that approximately 70% of salmon returning to spawn are commercially harvested. This is then described as a managed and sustainable landscape. Maintaining a sustainable resource is not an accurate characterization of a nearly pristine ecosystem. First of all, sustainability means a lot of different things to different people. For example, forests in the Pacific Northwest are managed in a sustainable way but the ecosystem is hardly pristine. Hilborn (2005) discusses the multiple definitions of sustainability. Instead of deciding which definition he likes the best, he indicates that sustainability is like good art, it's hard to describe but we know it when we see it. Second, Hilborn (2005) states: "The record shows clearly that almost all forms of human activity – agriculture, forestry, urbanization, industrialization, and migration – reduce biodiversity of natural flora and fauna. This is almost certainly the case with fishing as well." Hilborn acknowledges the sustainability of the Bristol Bay fishery but I doubt if he would claim that there is no impact of the fishery on the ecosystem of Bristol Bay.

   Rather than emphasizing the nearly pristine conditions and sustainability of the fishery, I suggest that other measureable characterizations of the aquatic and terrestrial ecosystem be measured and quantified. For example, a description of plant communities and succession would provide the reader with a better understanding of how plant communities are maintained, and subsequently, how proposed mining activities might alter the successional processes. Failure to address and understand such relationships led to unexpected consequences for down stream plant communities, wildlife diversity and village residents in the Peace Athabasca (Cordes 1975) Delta when the Bennett Dam was built hundreds of miles up stream on the Peace River. The Bristol Bay assessment would be improved if the expected changes in the hydrographs and sediment transport were related to the successional processes that maintain early successional plant associations such as the alder-willow association, which is important for moose. The write up for moose (Appendix C, page 33) indicates that these early successional associations are maintained by bank scouring. It would be good to know the role of ice dams and anchor ice on current levels of scouring and how changes due to mining might alter these important sustainable functions. The assessment's emphasis on fish and fish mediated impacts runs the risk of missing possible impacts on the terrestrial environment that would not only influence human culture, but also the aquatic environment. The impact on terrestrial resources is not inconsequential to aquatic resources, at least in my opinion.

4. The assessment's emphasis on marine derived nutrients and the reduction of this salmon derived resource only looks at a one-way, fish-to-wildlife interaction. Wildlife functions such as beaver dam building are very important wildlife-to-fish interactions. Both salmonid fish, as well as forage fish, receive benefits from beaver functions such as tree felling, dam building and food storage (Snodgrass and Meffe, 1997; Schlosser and Kallemeyn, 2000). This issue is briefly mentioned in Section 5.2.1.2, para 1 and is discussed on pages 5-19 and 5-22, but needs to be expanded. The dynamic process of dam construction and dam decay is important not only for moving streams across the flood plain, but also for creating a mosaic of plant associations and wildlife (e.g., moose) habitat in and near the floodplain. In addition, such activities create habitat for forage fish. An accurate characterization of the impact of a potential mine and road necessitates not only an assessment of the loss of fish on wildlife, but also the loss of wildlife and their functions on fish. The influence of wildlife and terrestrial processes and functions on fish discussed in the Cederholm papers needs to be included in the problem formulation step. The dynamic process of beaver dams causing creeks to move across the floodplain should also be a criterion for determining if and where culverts are installed for a potential road (page 4-36 and 4-63).

5. The multidirectional interaction of fish and wildlife is facilitated by an approach developed by the Northwest Habitat Institute Johnson and O'Neil (2000), and is also on the Northwest Habitat Institute web site (nwhi.org). The Interactive Biodiversity Information System (IBIS) database allows an assessment of fish and wildlife interactions and <u>functional</u> characterizations (i.e., ecosystem functions). The IBIS database is a logical extension of the Jack Ward Thomas Wildlife Habitat Relationships and the GAP analysis for the Pacific Northwest. Such an analysis could build on information in the Alaska GAP database and the Natural Heritage Program database in Alaska.

6. The amount of information in the assessment pertaining to ecological risk assessment and toxicology is impressively large. The amount of time and team expertise needed to adequately review this information is well beyond the scope of the proposed review. If a team was assembled to review this information, I would ask them to consider the applicability of a probabilistic risk assessment to address some of the uncertainty associated with the deterministic information presented in the assessment.

V. SPECIFIC OBSERVATIONS

David A. Atkins, M.S.

I have no specific observations for this draft, but will provide in the final draft.

Steve Buckley, M.S., CPG

Page	Paragraph or Line #	Comment or Question
xii	1	ICF is referred to in the document page xvi, but not listed as acronym or abbreviation.
ES-2	P2 line 5-6	"altered by geologic processes but would not degrade…" is unclear.
ES-24	P4 line 2	"geologic defects" is unclear.
1-1	P3 line 1	" 17 existing mine claims…" should read "existing claim blocks"
4-11	P3 line 10	"North pers.comm." There is no reference, date or information on North.
5-20	P4 line 3	The "northeastern United States" not comparable to western Alaska.
7-1	P1 line 5	"claims blocks" should read "claim blocks."
7-3	P3 line 4	As above.
7-6	P2 line 5	As above.
7-7	P2 and P4	As above.
8-1,2	P3, P2	In the discussion of removal of stream kilometers and wetlands it would be helpful to express these numbers in a percentage of the overall watershed stream kilometers and wetlands to put perspective on these numbers.

Courtney Carothers, Ph.D.

Page	Paragraph or Line #	Comment or Question
ES-2	3rd paragraph (p)	"wildlife and the Alaska Native cultures *of this region*."
ES-5	2nd p	"Chief among these resources are world-class commercial, sport, *and subsistence* fisheries for Pacific salmon…"
ES-8	Last p	1. Should Alutiiq (Sugpiaq) cultural group also be included? Alutiiq residents noted in Igiugig and Kokhanok (Appendix D, p 15). 2. Change 2nd sentence to: "In contrast, the salmon base upon which indigenous peoples in the Pacific Northwest depend is severely threatened" – shift focus from the cultures being severely threated to the fish being severely threatened. Some argue that with a depletion of resources comes a large threat to cultural continuity, others argue cultures adapt and change as the resource base does.
ES-9	1st p	"Salmon are integral to the entire way of life in these cultures as subsistence food, *fishing and subsistence-based livelihoods*, and as the foundation for…"

Courtney Carothers, Ph.D.

Page	Paragraph or Line #	Comment or Question
ES-9	2nd p	"52% of the subsistence harvest, *although for some communities this proportion is substantially higher*" (e.g., noted to be as high as 82% on pg 93 of Appendix D)
ES-10	1st p	Could also add replacement value for subsistence resources or for salmon, and the range of estimates for economic valuation of subsistence presented in Appendix E, noting that economic valuations do not fully capture the value of these practices.
ES-14	#1	Are these all the fish spp at risk, or only the one deemed to be commercially, recreationally valuable? Subsistence spp also include others. Should make clear what the focus is.
ES-23	3rd full p	As noted above, other mines in Alaska (e.g., Red Dog) and oil and gas development studies on North Slope may be useful to include predictions about how subsistence practices will change with mining development and perceived impacts. Including citations with these statements would be helpful.
ES-23/24	Last p	"if salmon quality or quantity is adversely affected *(or perceived to be affected)*"
ES-26	Last bullet point	There is much data on cultural disruptions caused by the Exxon Valdez oil spill, and cumulative effects of oil and gas development in North Slope region, current salmon shortages in Yukon-Kuskowkim. Clearly subsistence is not about lost food, but about lost lifeways, loss of practices, loss of teaching/learning, loss of identity. This point could be made more forcefully. While the specific impacts may not be entirely predictable, there are likely outcomes that could be included based on experiences in other regions of the state and/or world.
1-2	2nd p	"this assessment does not provide an economic *or social* cost/benefit analysis…"
2-15	1st p	Other important subsistence fish spp not listed in Table 2-5, e.g., whitefish and winter freshwater fish are listed as integral subsistence species in Appendix D. Again make focus here clear.
2-18	Section 2.2.4	The net economic valuation ranges presented in Table 73, Appendix E would be helpful to include here.

Courtney Carothers, Ph.D.

Page	Paragraph or Line #	Comment or Question
2-19	Last full sentence	"because no alternative food sources are economic viable." This is a bit of a misrepresentation. The point is that people choose to live subsistence lifestyles. Even if food at the stores was cheap, many would choose not to substitute for subsistence hunting, fishing and gathering. This narrow economic framing misses the cultural and lifestyle component of subsistence, and frames it merely as food procurement. This is not the case throughout the document, but in this instance, I would suggest changing this sentence to reflect the irreplaceability of the subsistence lifestyle (dependent on access to high-quality foods), rather than the economic viability of substituting alternative food sources.
2-20	First sentence	Here and in Appendix D, the legal framework for federal and state definitions of subsistence should be clarified. This sentence is a little misleading. Rural residents are given priority under federal law, and while the State of Alaska recognizes a subsistence priority, it does not differentiate between residents. Several times in Appendix D, an indigenous priority is noted (e.g., pg 88: "No other state in the United States so broadly grants a subsistence priority to wild foods to indigenous peoples as does Alaska."). If the authors are aware of other interpretations of state and federal law, they should include citations and additional clarifying information.
3-2	1st p	"would be benign or have no effect on the environment *or social systems*,"
3-4	1st p	"…provide subsistence for Alaska Natives *and others*." Particularly because subsistence is defined as a rural right in Alaska, all subsistence users should be included as potentially affected groups.
3-11	Figure 3-2E	This conceptual model appears less developed than the others. It would interesting to work on expanding it out to include missing dimensions; e.g., add health and healing activity (in addition to nutrition), cultural continuity (alongside social relations and linked to language and traditional ways of teaching). With a decrease in economic opportunities comes an increase in reliance on transfer payments. Overall it is a nice illustration, but strikes me as less complete than the others.
4-15	Table 4-3	1. Estimation of 200,000 metric tons of ore processed per day is much higher rate than any of the other mining operations listed in Table 4-4. Is this due to the low/moderate quality of the ore?
4-21	Last p	208 m high dam is "much higher than most existing tailings dams." What are average dam heights? Or how much higher than most existing tailings dams? Does this high height affect probability of failures?
4-23	2nd p	"a well field spanning the valley floor." This is unclear. Could it be added to Fig 4.7? How often would groundwater be monitored?

Courtney Carothers, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-48	1st full p	"effluents would be required to meet criteria." How different is treated discharged water from unaffected water?
5-59	2nd bullet point	Is there any information available on ore processing chemicals, how much are used, and likely toxicities?
5-76	Bullet list	The list of cultural factors that may be negatively impacted could include others: individual, community, and cultural identity; sense of place and place attachments; community sustainability; cultural unity/conflict avoidance.
6-46	Bullet list	In addition to the two listed, another should be added noted that subsistence practices (harvesting, processing, sharing, consuming) are important for psychological, social, emotional, and cultural health and well-being.
6-47	1st p	"…the physical, *psychological, and social* benefits of engaging in a subsistence lifestyle…"
6-47	1st p	Sources should be added (and were included earlier in report) for the statement: "would likely employ a small fraction of Alaska Natives."

Comments specific to Appendices:

Appendix D

- Single-space for consistency with the rest of appendices.
- The title is a bit misleading. Only eight pages in the report discuss traditional ecological knowledge, and here not in much depth.
- The research design, methods, and data analysis should be described in more detail. Clarify sampling procedure (both for communities and individuals). For example, it is unclear if younger generations, particularly active subsistence harvesters were targeted as well as elders and culture bearers. Interview protocol should be included clearly as an Appendix.
- This section may make a few overstatements (e.g., "only in Alaska are wild salmon abundant").
- P12 – "those outside of the state." Change to "outside the *region*," as many urban Alaskans are not familiar with subsistence communities.
- P12 – "Since the questions dealt with a cultural standard, there were few alternative points of views." Should cultural agreement be a matter of investigation rather than assumed? This statement needs to be justified. Perhaps with the authors' 40+ years of experience working with these communities they have come to expect cultural agreement, especially among elders. If this is the case that should be clearly. To what extent did group interviews (2-6 people interviewed together, except for one single interview) also contribute to cultural agreement? These details are important given that the results are given on an agree/disagree format.
- P17 – 2,378 listed in Table 2 and 2,329 listed here

- P19 – here is perhaps another example of overstatement – 100% of the population has access to waters of the rivers and lakes. What is meant here? For subsistence, this access depends upon having transportation and gear or social relations. Do 100% of people have this in this region?
- P20 – reword "the archaeological work is largely due to five projects."
- P26 – "located along a salmon stream indicates salmon were *likely* a primary resource."
- P31-32 – several of these quotes focus on social changes (e.g., elimination of dog teams, relationships to commercial fishing changing over time). People likely harvest less fish now because they do not support dog teams, yet now they need more money for fuel and equipment. These are important considerations for understanding contemporary mixed economy. These points are mentioned in this cultural characterization, but perhaps could be made a bit more clearly. At times even the contemporary characterization reads a bit like "timeless" traditional cultural relationships to the land and resources, yet it is important to accurately characterize the subsistence-based communities in their full contemporary realities and complexities.
- P34 – "Large disruptions to the population *have not been documented to* occur until epidemic…"
- P34/35 – both kashgee and qasgiq used for men's house – it is also defined three times over these first few pages of this section.
- P35 – "earlier bow and arrow wars" should either be explained or omitted.
- P38, first full paragraph, last sentence – What is meant by "observe the practice?" This general statement is not adequately supported. Authors should provide specific instances, or more discussion if this point is to be included. As written it risks conveying a static view of TEK and practice and culture. Many indigenous communities in Alaska, e.g., Kodiak villages, while exploited by a colonial economic system, also strategically adapted to benefit from those systems in ways compatible with their village lifestyles (e.g., cannery and village co-dependencies that elder fishermen in this region remember fondly; Carothers 2010). It would be helpful to have more information on this context in this region (e.g., Hébert 2008, Donkersloot 2005).
- P40 – more information would be useful on Alaska Native participation in commercial fishing in this historic period up through the present.
- P47-48 – Ellam yua and tnughit are defined twice,
- P81-84, Table 9 – second/third part of questions not explained. Since this is an agree/disagree table, remove other questions for which no information is presented. All questions would ideally be contained in an interview protocol attached as an appendix.
- P87 – 'non-monetized' – but important to note that modern subsistence economy now depends upon cash inputs (ATVs, boats, snow machines, gas, parts, repairs, guns, nets, etc.).
- P88, first full sentence, last sentence – poorly worded.
- P89-90 – the subsistence discussion is confusing.
- P92-93, Tables – update with recent data if possible.
- P100 – if percentage of working age population not in labor force is better measure, it should be included rather than official unemployment rates (or in addition too).
- P110 – "Villagers in the study also eat store-bought foods, but do not prefer them" – make clear again that most residents interviewed were elders or identified culture

bearers. A concern for many subsistence villages in other regions of Alaska is the displacement of younger generations from fish camp and other subsistence practices, and preferences for store foods, particularly candy and soda. If this region is unique in that regard, make that clear here.

- Section C "Physical and Mental Well-being" – subsistence for emotional/mental health should be added as a sub-section here. Given the high rates of social problems in Alaska Native villages (e.g., suicide, substance abuse, and domestic abuse), many cultures talk about subsistence practices as being healing activities or producing emotion, and spiritual and/or mental health. This important aspect isn't covered in the other sub-sections.
- P113 – Makhoul et al. is listed as 2010 in references.
- P114 – change Local Wild Fish *and Local Practices*, and "ecologically, *socially, culturally, spiritually,* and possibly even evolutionarily." Point is that subsistence salmon are not just vehicle for protein and nutrition, but form the basis of incredibly important subsistence ways of life that are irreplaceable.
- P115 – add 'cultural and social disruption' to the list of risks.
- P152, 2nd and last bullet points – these are risks of mining development, not of decreased quality/quantity of fish (defined as outside the scope of this assessment). The last bullet point would apply to fish-effects if reworded – some community members may decide it is not safe to eat fish causing factions of those who express concern and those who do not. Others to possibly include: cultural loss as younger generations do not learn the practices of subsistence; stress on other areas and communities of the region where people may target subsistence resources; health risks of eating contaminated fish
- P156 – sing to sign;
- Several grammatical errors throughout

Appendix E

- P9 – Components of total value should include indigenous homeland for Alaska Native cultural groups.
- P12 – Change Aleut to Alutiiq or Sugpiaq (pl. Sugpiat), or clarify usage
- P18 – direct spending on subsistence is included in the main report, and valuation is included later in this volume. Could include these values here, noting that only some of these values are in part captured by the market.
- P22 and 26 – change Boraas citations to Boraas and Knott.
- P32 – much of recreational use is non-market and could be included in the list at end of 2nd paragraph.
- P96 – citation for typical crew share of 10%?
- P122 Reasons for differences in earnings between local residents and others is important. The mixed subsistence-cash economy and cultural ideas about commercial work in this region may offer an explanation. See: Koslow 1986, Langdon 1986, and Carothers 2010.
- P134 – Ugashik, Egegik, and South Naknet have over 30.
- P136, last paragraph – This paragraph seems abrupt/misplaced. A more thorough discussion is needed here to include these points.
- P178, section 4.3 – no discussion of role of regional and village Native corporations or the Community Development Quota program for federally-managed fisheries.

- P191 – while the majority of formal sector jobs are taken by nonresidents, may want to note that local economy – subsistence – is all local and highly dependent on resources of the region.
- P193 – 2009 is mentioned as an unrepresentative year and given a sensitivity ranking of 'high.' More information should be included on the anomalous 2009 – in what direction should we expect to interpret data from this year compared to more average years, or those at other ends of the extremes?
- P195 – number of households engaged in subsistence – ADF&G data should provide estimates.
- P198 – ATV, snow machines, should be added to 'boats and trucks'; work by Robert Wolfe and Cheryl Scott and others (Wolfe et al. 2009) suggest that about one third of households in Alaska Native village harvest the majority of subsistence foods (and share, especially with the least active households). How does this finding affect these estimates?
- P202 – explain why % of adults with 4+ years of college was used in this model? The model was not explained clearly enough for me to understand it.
- Some fisheries, e.g., crab fisheries, were not included in economic analysis, yet depend in part on the Bristol Bay ecosystem, as discussed in Appendix F.
- References – Peterson et al. 1992 and Brown and Burch 1992 are not included in references

Appendix G

- Mitigation measures are largely concluded to be ineffective. It would be helpful to compare mitigation measures and their success/failure in other mining examples.

Appendix H

- P7 – exposure of groundwater and waterfowl to chemical contaminants are listed as main environmental concerns from tailings storage facilities. Impacts to human health from ingesting contaminated water or birds. Clarify in report that direct risks to human health are not accessed (only through reduction or elimination of subsistence harvests?).

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Dennis D. Dauble, Ph.D.

Page	Paragraph or Line #	Comment or Question
App. B, page 30		Table 1. I suggest adding a column to indicate relative abundance, for example, if individual fish species listed are abundant, common or rare. Also, are there known differences in distribution and abundance for the Nushagak and Kvichak watersheds relative to those watersheds unlikely to be affected by mining activities?
App. A page 42	1st paragraph	The statement that diminished salmon runs present a "negative feedback loop" where spawner abundance declines, appears to conflict with the last paragraph on page 41.

Gordon H. Reeves, Ph.D.

Page	Paragraph or Line #	Comment or Question
6-9	1	Why would resident fish not "suffer" immediate loss of habitat as a result of dam failure like anadromous fish would?
6-42	5	Couldn't fish move to another stream to spawn if a culvert is blocked and prevents upstream movement? This may eliminate the fish from a particular stream for a year but it might not reduce the overall productivity.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
Entire Assessment		Provision of full color versions of all figures would have been helpful to this review. The selected color versions supplied were useful – we should have had them all.
2-4		Color codes are confusing – use of different colors for same "moisture state" in the five regions doesn't make sense (to me).
3-4	3.4, line1	….when mine ***is*** active
4-5	last	Refers to Fig. 3-1, but "existing road segments" listed are not shown on Fig. 3-1, nor are several cited locales: Williams Port, Pile Bay, King Salmon, and Naknek.
4-11	first	"The vast majority of tailings dams are less than 30 m in height…" DOES THIS REFER TO TAILINGS DAMS AT ALL KNOWN MINING OPERATIONS, OR TAILINGS DAMS ENVISIONED OR PROBABLY TO BE USED IN BRISTOL BAY WATERSHED?

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
4-11	first	"Although upstream construction is considered unsuitable for impoundments intended to be very high or to contain large volumes of water or solids….this method is still routinely employed." ARE THE TSFs SUGGESTED IN THIS ASSESSMENT CONSIDERED "UPSTREAM", "DOWNSTREAM" OR "CENTERLINE"? Para. 1, Section 4.3.5 (p.4-21), states that " the most plausible sites" for TSFs are "the higher mountain which suggests that these TSFs would be "upstream" facilities, therefore "considered unsuitable……"
4-23	2nd para	Text suggests that a monitoring well field downslope from the TSF (and presumably from all hypothetical TSFs) would detect seepage; such seepage would then be intercepted and either returned to the TSF or "treated and released to the stream channel." Either action presupposes adequacy of monitoring seepage and subsurface flow (both spatially and temporally); returning such water to the stream further presupposes fully adequate treatment to meet both regulatory and aquatic biota requirements for water quality and flow regime.
4-26	Section 4.3.7, pp. 4-26 – 4-28	This "Water Management" section seems cursory, highly generalized, and optimistic. Statements such as "uncontrolled runoff would be eliminated", "water from these upstream reaches would be diverted around and downstream of the mine where practicable", "Precipitation…would be collected and stored….", do not indicate actual (proposed) practices or techniques, nor inspire confidence that actual runoff events during "normal" conditions, let alone during hydrologic extremes (such as a rain-on-snow event with underlying soils still frozen), would be planned for or actually managed adequately.
4-29	first para.	Suggests that 20% more water than available would be required "during startup", and that difference would be satisfied "from water stored in the TSF"; if 20% more than is available would be needed, where would it come from, to be available from the TSF?
4-29	third para.	Assumptions are very generalized and optimistic: "assuming no water collection and treatment failures", "excess captured water would be treated…and discharged to nearby streams…." – this assumes both "no failures" over the life of the operation, and that such treated "excess captured water" could be successfully treated before release, to fully meet both regulatory water quality criteria and the possibly more sensitive biological requirements of individual invertebrates and fish stocks (Appendix A, Appendix B).

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
	4.3.8 – Post-closure Site Management	This and the previous section mention (but in my view do not adequately stress) the extremely long time frame for post-mining active management and oversight. Many hundreds of years of active management is a longer time than many industrial, corporate or governmental entities are capable of really embracing – witness the current US congressional practice of "kicking the can down the road" – a human trait.
4-32	4.3.8.2, third para.	Suggests that pyritic tailings could be "shipped off site" – i.e., to where? Deep ocean dumping, or Yucca Mountain?
4-34 - 4-37	4.3.9 – Transportation Corridor	This reviewer finds the short Transportation Corridor sub-chapter to be succinct, but inadequate and superficial in view of the long-term consequences of imposition of the transportation corridor as portrayed. These deficiencies are addressed, in part, in other sectors of the Assessment, most comprehensively in Appendix G.
4-38	Box 4.3, Para. 2	Para. 2 states that the southwest extension of the Lake Clark Fault is currently understood to extend to perhaps 16 +/- km from the Pebble ore deposit; however, this is not reflected in Figure 4-11, which suggests that the Lake Clark Fault terminates perhaps 100 km northeast of the Pebble locale. Elsewhere in Box 4.3 there is acknowledgement that, while there is no evidence of recent tectonic activity in the immediate Pebble vicinity, there is relatively little site-specific data or long-term historical seismic record; I infer that any predictions concerning seismicity or earthquake occurrence of any magnitude would have very high uncertainty.
4-41	Box 4-4	Note that in each of the four tailing dam failure examples, the failed structure was roughly an order of magnitude **smaller** (in height) than the hypothetical TSF-1 structure, yet those failures had major negative consequences.
4-45 – 4-47	4.4.2.2	The probability approach to tailing dam failure is unpersuasive as presented. It is difficult to relate to a number like "0.00050 failures per dam year", or to the implication (p. 4-47) that one can expect a tailings dam failure only once in 10,000 to one million "dam years". This could suggest to the casual reader that failure of the hypothesized TSF1 dam (for which one "dam year" is one year) should not be anticipated in either the time of human occupation of North America, or the span of human evolution.

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
4-48		Box 4-6 suggests that the Operating Basis Earthquake (OBE) for a 7.5-magnitude event at the Pebble locale has an estimated return period of 200 years. Such a return interval probability is difficult interpret, given the lack of historical seismic record for the region; in any event, such a return period estimate is in no way predictive of future seismic activity, in year 2012 or year 2212. Box 4-6 does note that "The return periods stated in Alaska dam safety guidance are inconsistent with the expected conditions for a large porphyry copper mine developed in the Bristol Bay watersheds, and represent a minimal margin of safety."
4-50 – 4-60	4.4.2.4	The modeled hydrologic consequences of overtopping/flooding of the hypothetical TSF1 dam/reservoir seem reasonable, given the relatively limited hydrologic data set available for model input. Probable Maximum Precipitation and Probable Maximum Flood results should be approximately "correct" and within the same order of magnitude of potential storm and flood events. The potential consequences outlined (peak flow volume, sediment transport and deposition, length of stream corridor impacted) appear realistic for the scenario. Suggest that this topic and hypothetical result should be given more visibility and emphasis in the assessment.
4-62 – 4-63	4.4.4	While accurate, this section does not adequately address the road/stream crossing/culvert issue. Given the projected transportation corridor, Pebble locale to Cook Inlet, and the inevitability of a further network of "minor" roads in the mine and TSF locale, plus additional infrastructure linkages, road/culvert/stream crossings is a major concern for aquatic habitat and fisheries. This issue receives more attention in Sections 5.4 and 6.4, and is mentioned elsewhere in Volume 1 (e.g., Table 8.1, Box 8-1, para. 8.1.2.4.). Readers of the Assessment should be directed to Frissell and Shaftel's Appendix G for a more comprehensive discussion of this important topic.
	Chapter 5	Assumes scenario of "no failure" for entire project, over complete project life. Is this a realistic scenario, given experience with industrial developments in real-world settings subject to vagaries of equipment, landscape, geology, weather, local climate, and human judgment and decision making/execution?
5-1	5.1.1	Question: is "sampling extensively for summer fish distribution over several years" adequate for characterizing fish populations, given the wide fluctuations in salmon escapement and return note elsewhere in the Assessment (e.g., Table 5-1, para. 5.1.2)?

Charles Wesley Slaughter, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-12 – 5-48	5.2	Estimates of habitat, wetland and stream blockage or loss seem reasonable, but as noted in the text, are probably conservative or "at the low end". Estimates of probable streamflow diminution (p. 5-25) seem reasonable, but make no reference to seasonality.
5-29 – 5-30	Thermal regimes	This section makes no mention of aufeis or "nalyds", ice accumulations which can exert major control on spring and early summer habitat availability and thermal conditions. (for examples, see Slaughter 1990, among many other references)
5-30 –5-31		Concur that maintenance of natural flow regime is the desirable target; the "sustainability boundary" approach is a way to attempt managing within the "natural" bounds of variability. Note: 5-9 is map of streams and wetlands lost, not predicted flow alteration hydrograph (see last sentence, p. 5-31).
	Figure 5-10 Upper Talarik Creek	UT100D – predicted flow is ALWAYS below lower 20% sustainability boundary. UT100C, UT100C1, UTC100B – predicted flows are always with in the 20% +/- sustainability boundaries.
	Figure 5-11 South Fork Koktuli River	Predicted flow for two upper gages (SK100G, SK100F) is always below the 20% sustainability boundary. Predicted flow at other gages appears to be near or within the 10% and 20% lower sustainability boundary.
	Figure 5-12 North Fork Koktuli River	Predicted high flow for NK119A is far below the lower 20% sustainability boundary throughout the open water season. From onset of snowmelt, flow at other gages is roughly at or within the lower 20% sustainability boundary.
5-41		Gage NK119A – is the estimated decrease of streamflow (minimum mine size) 63% (Table 5-13) or 73% (text)?
		In any case, text is clear: predicted flow reductions for North and South Forks Koktuli River are materially below the lower 20% sustainability boundary. Text suggests that while upper Talarik Creek would be essentially obliterated in this hypothetical scenario, lower gaging stations on Talarik Creek might have partial augmentation of reduced flows, from small tributary flows and groundwater; without supporting data, this suggestion seems unsupportable.
5-42 – 5-45		These pages fairly summarize the potential for substantive alterations to streamflow regime and surface water/groundwater relationships.

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Page	Paragraph or Line #	Comment or Question
5-44	3rd para.	"Once the mine is no longer a net consumer of water, we assume that flow regulation through the water treatment facility could be designed to somewhat approximate natural hydrologic regimes, which could provide appropriate timing and duration of connectivity with off-channel habitats." I suggest that this is a highly optimistic assumption, and does not address water quality questions (which are raised elsewhere in the Assessment).
5-45	5.2.3	This entire paragraph should receive greater emphasis.
5-46	Para. 4	Ignores variable-source-area concepts, which are widely accepted in hydrologic and watershed analysis.
5-46	Para. 5	Assumes requirement for more water than is available, but leaves hanging the question of where that more water might be sourced. Given that the site is a watershed headwaters, what might be tapped as additional water supply, and what might be the impacts on that source(s)?
5-59 – 5-63	5.4 Roads and Stream Crossings	See earlier cautions concerning stream crossings, culverts. Note that road cuts and culverts are particularly susceptible to development of aufeis ("icings"), often resulting from blockage or alteration of subsurface water movement during cold conditions, as witnessed by long-standing AKDOT maintenance issues – Richardson, Steese, Dalton highways, for example.
5-60	5.4.2 -- 1st para.	The statement that "…it is unlikely that a mine access road would have sufficient traffic to significantly contaminate runoff with metals or oil" is unsupported; it might be instructive to look at traffic loads for the access road from the Steese Highway to the Ft. Knox mine, a much smaller operation than the proposed Pebble development.
5-60	5.4.2 – 2nd para.	First sentence is correct. Second sentence is unsupported and probably incorrect (see Appendix G). Yes, runoff from roads is location-specific; that **does not** mean that runoff from roads would be insignificant to salmonids, given the very large number of streams (perennial, intermittent, and ephemeral), and wetlands, which would be intersected by the total road system of the Pebble project. This also seems to be contradicted by 5.4.3.
5-60	5.4.4.1	There are many more water or seep crossings than 34 – see USGS topog sheets, or Acmemapper or Google Earth.
5-61	5.4.4.2, 5.4.4.3	Development of aufeis ("icings") consequent to partial or full culvert blockage, or induced by soil mantle compaction (i.e., by roads or off-road vehicle traffic) can partially or wholly block stream channels; such blockage, in association with ice on the streambed, may last long past snowmelt and persist well into early summer, possibly affecting fish movement.

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Page	Paragraph or Line #	Comment or Question
5-62	5.4.5	While I don't have the specific citations at hand, there are published analyses of dust effects associated with the North Slope haul road and Prudhoe Bay road network. Obvious effects include accelerated snowmelt along the road corridor, and nutrient or pollutant contributions to road corridor environs.
5-63	5.4.6.3	Should it read "…..*impacting* 270.3 km of stream…"? (Incidentally, it is interesting that this coarse assessment finds it possible to state impact to within 100-meter resolution).
5-65	5.4.7.3 (and 5.4.8.3)	Viewing the transportation corridor landscape, via maps, Google Earth or Acmemapper, gives me the impression that the estimate of 4.9 km2 wetlands directly impacted is a very low number. It is easy to play with the numbers given on p. 5-69 – 5-70, regardless of their accuracy; 66 km of road impacting wetlands, assuming a 10-meter roadway footprint, yields 0.66 km^2 of wetlands "under the road" (vs. 0.18 km^2 in the text); the 200-meter proximity to wetlands cited, over 66 km of road, yields some 13 km^2 of wetland impact (vs. 7.3 km^2 in the text). 80 km of road within 200 m of streams or wetlands yields 16 km^2 of road/wetland impact. Since these are all assumptions and estimates, it is not possible to conclude that any of these figures would be the "true" area impacted.
5-74	5.4.10	Should this say ***impact*** rather than "risk"? Text implies that even this "no-failure" scenario will impact salmonids; however, it is apparently not possible to estimate specific changes or the magnitude of such changes.
5-74 – 5-77	5.6	This section seems cursory and understated, particularly in view of the extensive discussion of Appendix D
	6.1	Concur with general overview statements, and with conclusions regarding immediate consequences of TSF dam failure, which would likely be as severe as or more severe than stated in 6.1.2.1. P. 6-6, first sentence – note that the failure scenario predicts over 70% fines <0, 1 mm, vs. the 6% "natural" fines concentrations. P. 6-13, last para. – The assumption that overtopping would not occur in winter is not warranted, as the authors admit when citing the Nixon Fork Mine incident. In the Bristol Bay environment, a major rain-on-snow event in winter or spring is within the realm of possibility, and of course human error is, if not inevitable, always possible.

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Page	Paragraph or Line #	Comment or Question
6-15	Box 6.2	Box text implies that human error, lack of timely oversight and correction was responsible – but never directly says "human error". The apparent assumption that there is no hydrologic activity after freeze-up (or perhaps, after an ice cover forms on the pool) was naïve and incorrect. At least in that case, it appears that both dam and spillway design (not adequately considering winter and ice conditions) and operation/inspection (human error) were responsible.
	6.1.4.1	Appropriately recognizes the long time period for exposure, over extended stream lengths, through both initial deposition and multiple re-mobilization and redeposition events.
6-28	6.1.5 and Table 6-6	Seems jargon-laden, does not add to strength of the Assessment.
6-29	6.1.7	Concur that remediation "…would be particularly difficult and damaging…."
	6.2	Even though "We do not assess failures of the natural gas or diesel pipelines…", those pipelines would be equally susceptible to failure as the slurry line. Concerns with pipelines crossing streams, watercourses and wetlands are similar to those earlier expressed for the road corridor. Similarly, I suspect that careful inspection would reveal many more "watercourses" (including intermittent and ephemeral streams), than the 70 crossings cited. The "probability" argument of p. 6-32 is an understandable attempt at quantification, but is unpersuasive. Given the spill history of TAPS, pipelines in the Prudhoe Bay field, and recently in Montana (?), suggesting the probability (with what confidence limits?) that there "should be" only 1.5 stream-contaminating spill in78 years of operation seems wildly optimistic Assuming that any spill (over the 78-year project span) would last only two minutes (p. 6-32, 6-34), with a consequent minimal volume of spilled material, also seems highly optimistic. Even highly-automated systems, with redundant sensors and automatic responses, are susceptible to error or failure, and the Bristol Bay watershed environment is not benign with regard to mechanical apparatus. The authors appear to recognize this with their discussion of the Alumbrera incident.

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Page	Paragraph or Line #	Comment or Question
	6.4	Potential road/culvert failures are recognized (again, note that ice issues are not discussed). Extended periods for repair/rebuilding might be anticipated – witness the repeated problems with the highway to Eagle AK over the past several years—and that is a State of Alaska responsibility, not that of a private company. Potential for multiple simultaneous or concurrent failures is appropriate. Non-Alaska examples would be the Pacific Northwest flood events of 1964 and 1996, both major precipitation events with widespread flooding and road failures, in a region with much more developed infrastructure and response capacity.
	7 – Cumulative Effects	Recognition of probable additional mining activity, in the wake of a Pebble project, is appropriate. Assessment is necessarily limited to currently-known potential mining projects. The cumulative and irreversible consequences of multiple developments, with associated road, power, housing, communications infrastructure ("secondary development"), should be more heavily emphasized, even though it is not possible to quantify all those consequences.
	8 – Integrated Risk Characterization	8.1.2 – note many potential failure modes not analyzed; the lack of analysis in this Assessment should not be taken to mean that such failure could not or will not occur.
	Table 8.1, Row 2	Table 8.1 – row 2 – the reasoning behind the statement that "Most [product concentrate pipeline] failures would occur between stream or wetland crossing [sic] and might have little effect on fish" is hard to understand; stream crossings, whether via elevated utilidors or via sub-channel borings or utilidors, are locales of angular change, piping connections and joints, and subject to stresses of hydrologic extreme events – so why would such sites be less subject to potential pipeline failure?
	Box 8-1	As noted elsewhere, the probability arguments for TSF dam failure are not persuasive, and seem designed to imply that a TSF dam failure would not occur within the next 10,000 years (or 3,000 to 300,000 years with three TSFs operational). This implication is difficult to square with information on actual past failures presented in Box 4-4 and Table 4-8

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Page	Paragraph or Line #	Comment or Question
	Chapter 8	The potential risks and impacts are fairly and succinctly stated. Given the extremely long-term nature of the projected Pebble project, and the irreversible changes which would be imposed to the region, the risks seem if anything understated. I attribute this to the decision to focus this Assessment on salmon and anadromous fisheries, with some attention on salmon-mediated impacts – i.e., effects on indigenous culture, on wildlife other than salmon, etc.

Additional references, which may be useful:

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Page	Paragraph or Line #	Comment or Question
ES-9		Economics of Ecological Resources. This section seems weak.
ES-14		Overall risk to salmon and other fish. Never really does separate fish species out in other discussions. Dolly varden more sensitive to metals?
ES-24		Cumulative effects-as mentioned earlier not really a cumulative risk discussion.
2-3	3	Four climate classes. Why this classification system? Perhaps easier to identify by watershed maps?

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Page	Paragraph or Line #	Comment or Question
2-5		Precipitation values. Significant figures?
2-23		Monthly values of streamflow. Would be nice to see average or daily streamflows somewhere.
3-7 to 11		Would like to see more discussion of conceptual models. If a picture is worth a 1000 words…
4-1	1	*...reflect current good, but not necessarily best, mining practices.* Why not use the best methods or state of the art methods?
4-18		Shaded relief. Perhaps contour lines in another figure?
4-21	1	*...most plausible sites given geotechnical, hydrologic, and environmental considerations.* Can this be elaborated?
4-21	2	*...the TSF would be unlined other than on the upstream dam facem and there would be no impermeable barrier constructed between tailings and underlying groundwater.* Is this correct? I thought I read the whole TSF would be underlain by liner?
4-24		Leachate Recovered. Does this refer to only the leachate collected from the dam face?
4-26		Water management. This is confusing. Collect precipitation for processing, yet divert upstream waters around the mine and not use? Where are the leachate recovery wells and are they just a safeguard?
4-28		Significant figures on precipitation estimates? What is the ET and how is it calculated?
4-31	3	*...the mine pit would take approximately 100 to 300 years to fill.* From groundwater inflow only? Why such a large range of the estimate?
4-50	3	The comparison is unclear for a 3313 cms flow in a 2551 km2 watershed area, to the TSF flow of 1862 cms and an area of 1.4 km2? What was the precipitation and recurrence interval for the Ekwok storm?
4-52		What is the recurrence interval of the 356mm?
4-60	4	Why a geometric mean using 3 values?
5-10		Definition of *highest reported index spawner* .
5-20	1	*...salmon abundance related to pool size....and beaver ponds provide particularly large pools.* Are data available to characterize the stream type? Are beaver present?
5-22	2	*Assuming that no natural flow or uncontrolled runoff would be generated from the mine footprint...* Is all the precipitation intercepted or does this refer to the subsurface streamflow generation mechanisms?
5-23		It appears that the mean annual unit runoff is calculated incorrectly.
5-24		Table shows flow returned from footprint? Does not fit with page 5-22.

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Page	Paragraph or Line #	Comment or Question
5-29	2	Groundwater-surface water connectivity. Are data available to show this connection throughout the watersheds or does the groundwater only return to the hyporheic in the low gradient areas? Similarly, where are the temperature data that suggest the lake and groundwater connection or this reference by incorporation?
5-32-39		The tables and hydrographs illustrating the potential flow changes are difficult to appreciate or interpret. Another means of presentation?
5-41	1	The value of 0.15 km affected by the maximum mine size is questioned.
5-52	Table 5-17	Can we see summary statistics on water quality, not just means? Plot of concentrations with streamflow?
5-55		*These effluent specific values are higher than those for background surface water because of the higher content of mineral ions.* This sentence needs clarification.
6-6	Table 6-1	Last line. What is the +/- value after the mean?
6-13	3	…*an intense local storm*…Why use the Type 1a distribution for precipitation distribution?

Roy A. Stein, Ph.D.

Page	Paragraph or Line #	Comment or Question
Document	See Table 5.3 as an example	Some thought should be given to significant figures for the numerical values given in the report, especially so for Chapter 5, where much uncertainty exists re stream lengths blocked (for example) by the mine footprint: "…34.9 km of first- through third-order streams…" will be eliminated. Rounding in this context makes sense for we really do not know this impact to the nearest 0.1 km. I would encourage a thorough review of these values throughout the report.
2-17		Salmon populations are closely managed by ADFG; how closely and what do we know of the populations that are managed re numbers, resilience, variability, etc.? A box summarizing the fishery management practiced by Alaska Department of Fish and Game would help put biological resources in perspective.
2-17		The importance of salmonids to marine predators is likely not an issue, given the very large numbers of salmon stocked in the Pacific.
2-20		Nushagak and Kvichak rivers contain >58,000 km of streams; 13% is anadromous fish habitat, but this is likely underestimated. How do we know this is an underestimate? What proportion of this >58,000 km has been surveyed?
2-24	5th text line	"the" is missing between "…of" and "nutrient budgets…"

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Page	Paragraph or Line #	Comment or Question
2-25	bottom of page	I wonder if a bit more couldn't be written about the idea of a salmon sanctuary, fleshing out the ideas of Rahr and Pinsky here.
3-2		With all the items in the first full paragraph eliminated from consideration (e.g., power generations, worker housing, Cook Inlet Port), might the analysis herein be considered minimal impact on the Bristol Bay Watershed?
3-7 to 3-11		These conceptual models might best be placed in the chapter to which they refer; in so doing, it is easier for the reader to follow along. In turn, these models did not seem to be discussed in text to the extent that they drove the impacts generated. Add more explanatory text.
4-5	bottom of page	Typically, when citing a figure in another chapter, i.e., one not near the current text, the format should be "see Figure 3-1" to keep the reader on track.
4-8		Is there some chance of "block caving" here? Some text clarifying this point here would be appropriate.
Chapt. 4		Could these data and insights be productively moved to Chapter 5 thus reducing redundancy? The organization would be 1) a description of the mine features relevant to the text, then 2) a discussion of salmon and the mining impacts on their habitat. Separating these into chapters seems artificial.
5-20	3rd full Par.	What does the phrase, "free-water area" mean? Ice free, perhaps?
5-20 to 5-21		Paragraphs on these two pages reflect some of the redundancy that I saw throughout the report. In the 3rd full paragraph on page 5-20, text begins with "…groundwater inputs may be critical…" and in turn on page 5-21 in the first full paragraph, the topic sentence begins "…groundwater-influenced stream flow…likely benefit fish…". Both deal with the same topic. Hence, these two paragraphs could easily be combined, serving to shorten the text, reduce redundancy, and improve readability.
5-22		Similarly, the text on page 5-22 includes citations (at the end of the same sentences) to both sections and tables and figures in Chapter 4. This suggests to me that the text is not only overlapping, it is redundant and better overall report organization would serve its presentation well.
5-23	Table 5-5	Some explanation in the table title would benefit the reader, as to where these gages are placed in the stream. The labeling is arcane at best UT100D; letters suggest Upper Talarik Cr., but what is 100D. Now, I figured out from text that the first ones were high in the watershed and then they proceeded downstream (increasing drainage area gave me a hint as well). Use better descriptors (such as SK1 through SK5 from low to high stream order) or explain the ones that are being used.

Roy A. Stein, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-26	Table 5-7	I cannot find any bold in this table that would reflect the pre-mining condition. Is that the same column as "Pre-Mining" as it is in Table 5-8 on page 5-34 (and the next few tables as well)?
5-27		Cite Figure 5-8 in text any time the stream gages are mentioned. The reader then has the ability to easily refer back to stream gage locations.
5-32 to 5-39		How do these tables and figures differ? Might they be 10% reduction in flow, 11-20% reduction inflow and >20% reduction in flow, as suggested in text? If so, then these table and figure titles need to reflect this information and be better described in the legends of the figures. Finally, do we need both tables and figures?
5-31		The Richter et al. (2011) reference which underpins this section is incomplete in the Literature Cited (Chapter 9), suggesting only March as the publication date. Update in any revision.
5-31		It should be made clear that the Richter et al. (2011) sets quite specific bounds for all rivers re ecosystem function and does not provide any specific insight into salmon production (made somewhat clear in the last sentence of the next to the last paragraph on page 5-43). I think an additional caveat stating this explicitly on page 5-31 would improve the text.
5-46		Stream flow losses due to the mine footprint are discussed first as underestimated, then as overestimated, and then a conclusion that they are underestimated (i.e., because the mine will need more water than is available from surface run-off). If this is the case, why go through the other scenarios…to seem even-handed? I am not sure all of this text is required.
5-46		Mine start-up will require more water than is available from the footprint of the mine itself. Hence, water will be captured from other streams than just those associated with the mine, which will influence stream flow and ground water supplies. Are there estimates of the amount beyond the surface water that will be required?
5-53 to 5-58		I am a little confused by this section. The implication throughout is that copper toxicity will be based on the response of aquatic invertebrates (which would then be protective of direct effects on salmon). However, near the end of this section, there is a discussion about zooplankton being most sensitive and a comment about the reliance of juvenile sockeye rearing in lakes on these zooplankton. Yet, there is no resolution of what criteria will be used for toxicity values…will it be aquatic invertebrates or the more sensitive zooplankton? Clarification is required here.

Roy A. Stein, Ph.D.

Page	Paragraph or Line #	Comment or Question
5-59		"Discharge permits for mine in the Bristol Bay watershed should include relevant whole-effluent toxicity testing and monitoring of biotic communities in receiving streams". Does this quote solve the problem mentioned in the previous comment? Is this a realistic expectation for mine operators before permits are issued?
5-68	Table 5-22	>10% rather than <10% in the table title.
Chapter 6		Rivers is lower case when multiple rivers are listed.
6-1		Why assume that only 20% of the tailings stored would be mobilized with any dam failure? Is there a justification for this important assumption? Yes, see Appendix I, page 14 for citation to Dalpatram (2011); this should be cited in the Main Report in Chapter 6.
6-4		Add map showing the impact of the failed TSF 1, i.e., distribution of sediments and impact downstream.
6-42		The sentence in mid-paragraph (3rd complete paragraph on this page) "…multiple failures such as might occur…" My guess is that an example should follow the phrase "such as".
7-2		The sentence at the end of the last full paragraph on the page makes little sense: "The overall consequences are diminished and extinct salmon populations."
8-6	2nd complete par.; last sentence	"further" should be "farther"; sorry, I just couldn't help myself…

William A. Stubblefield, Ph.D.

None.

Dirk van Zyl, Ph.D., P.E.

NOTE: I have indicated a number of specifics in the text above and do not have the time available to list these again as well as to add others. Those comments listed in the text above do not necessarily represent all the corrections and edits that should be made.

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Phyllis K. Weber Scannell, Ph.D.

Page	Paragraph or Line #	Comment or Question
Page 4-11		The document states "geomembranes are generally estimated by manufactures to last 20 to 30 years when covered by tailings (North pers. comm...)." Unless North is a P.E. with experience in geomembranes, the statement needs a stronger reference. For example, Erickson et al (2008)* discuss the quality issues with geomembranes related to manufacture, installation and application of a soil-based cover (such as bentonite).
4-23	1	This first sentence is confusing and implies that oxygen has low solubility because it is in the tailings pond. Suggested change: eliminate the first phrase "In a TSF".
6-36	P 3	Last sentence states: [water] treatment would continue until institutional failures ultimately resulted in abandonment of the system, at which time untreated leachate discharges would occur. This statement is not supported by any documentation and is not clear what is being implied. Failure of governments? As stated in my response to questions, any mine plan must include sufficient bonding and plans for reclamation, including necessary water treatment.
6-37	P 4	End of paragraph states "premature closure could leave waste rock piles in place." Again, there is a need for plans for mine closure, concurrent reclamation and sufficient bonding.

* Erickson RB, Thiel RS and Peters J. 2008. The Ongoing Quality Issues Regarding Polyethylene Geomembrane Material Manufacturing & Installation. The First Pan American Geosynthetics Conference & Exhibition. 2-5 March 2008, Cancun, Mexico

Paul Whitney, Ph.D.

A lot of page and paragraph comments are in the above text. I have no further comment.

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